

# CONCRETE AND CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

DECEMBER, 1954.



Vol. XLIX, No. 12

FORTY-NINTH YEAR OF PUBLICATION

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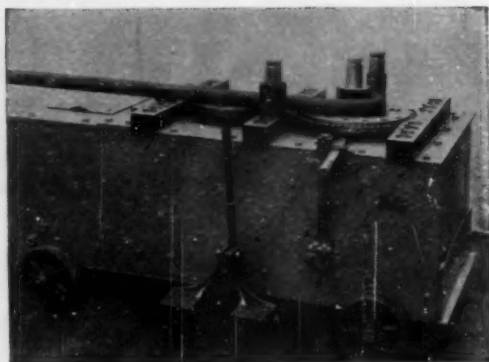
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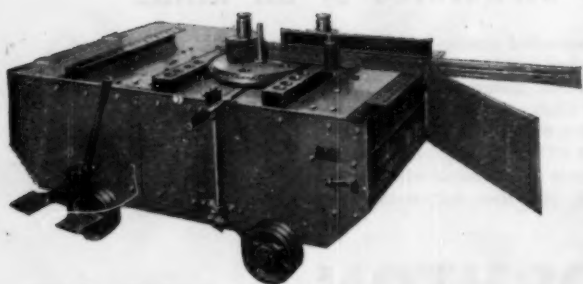
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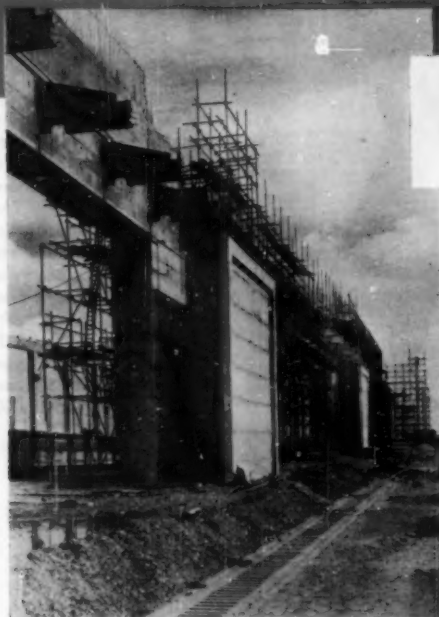
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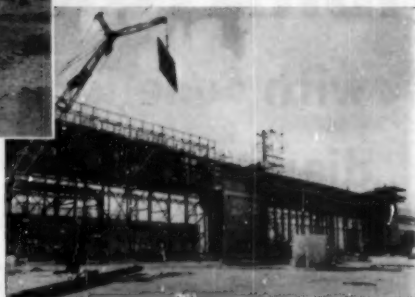
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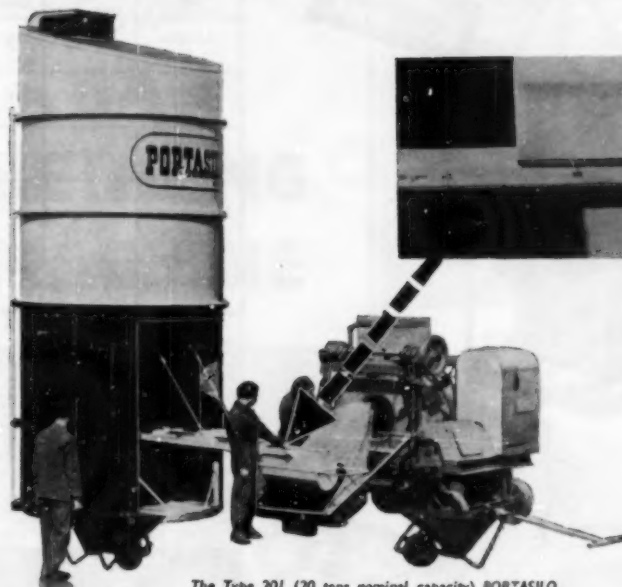
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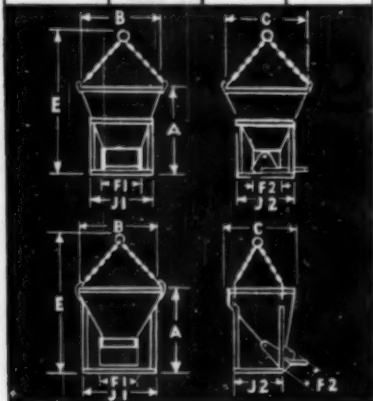


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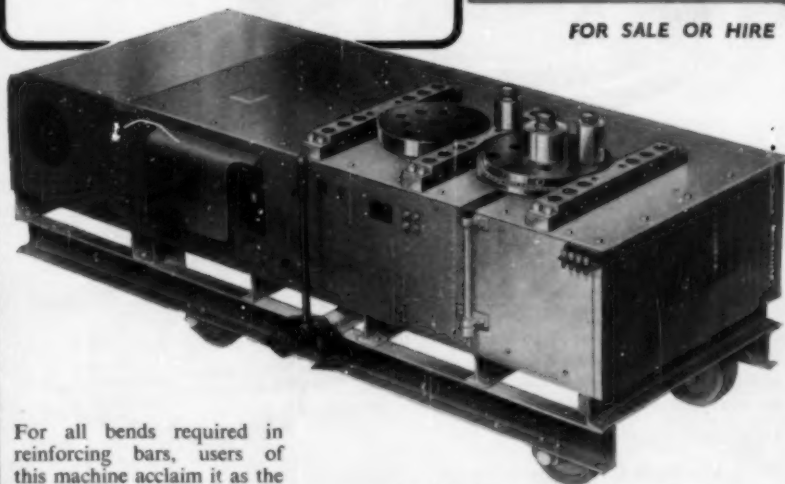
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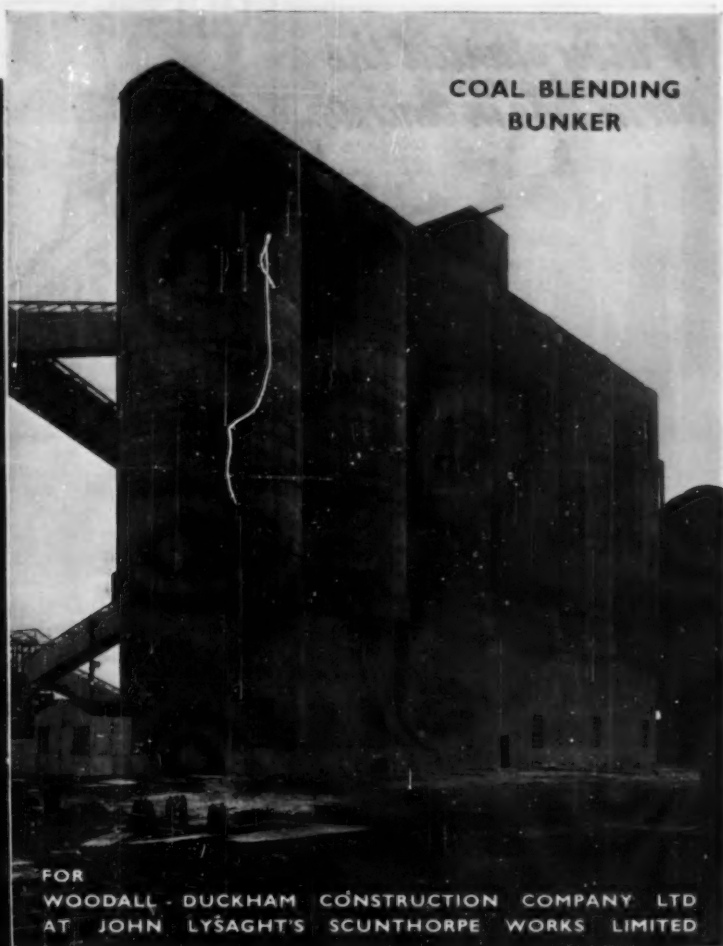
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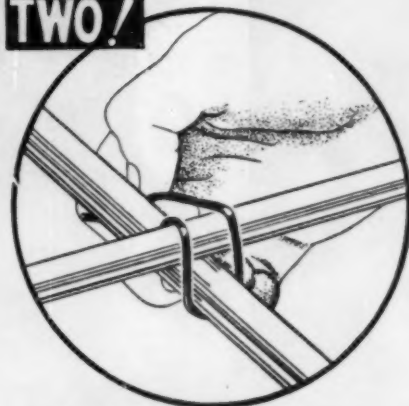
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**TWO!**



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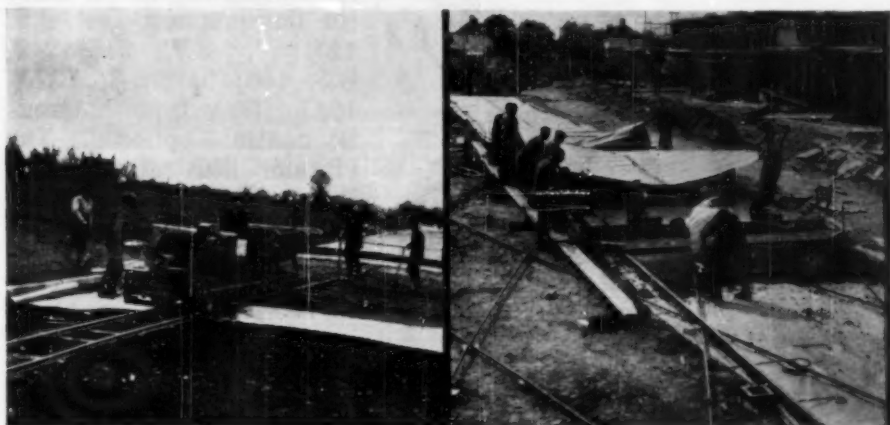
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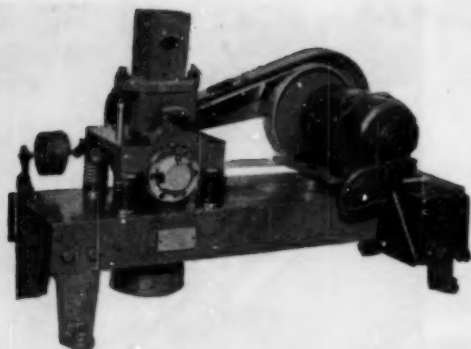
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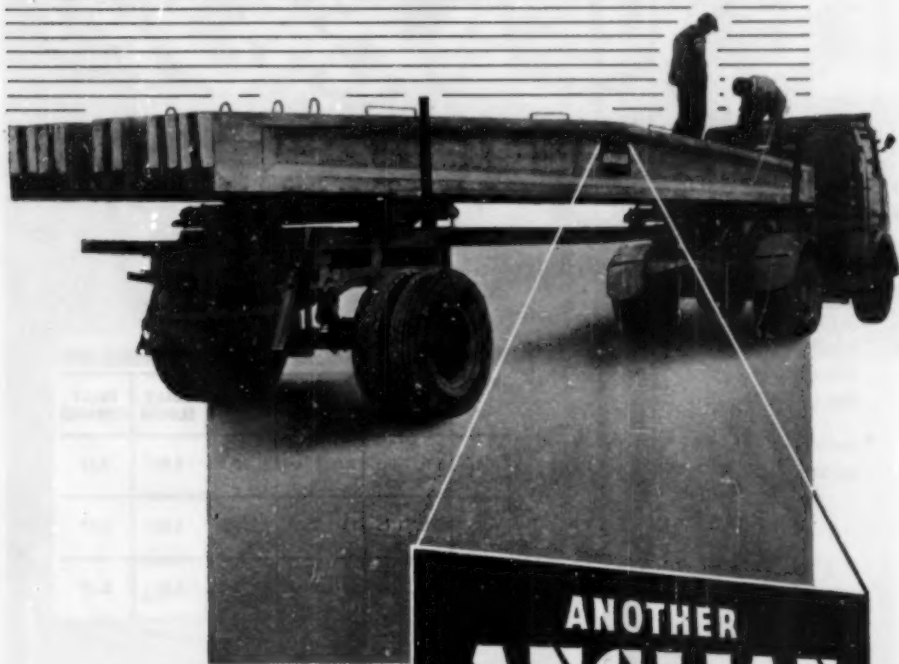
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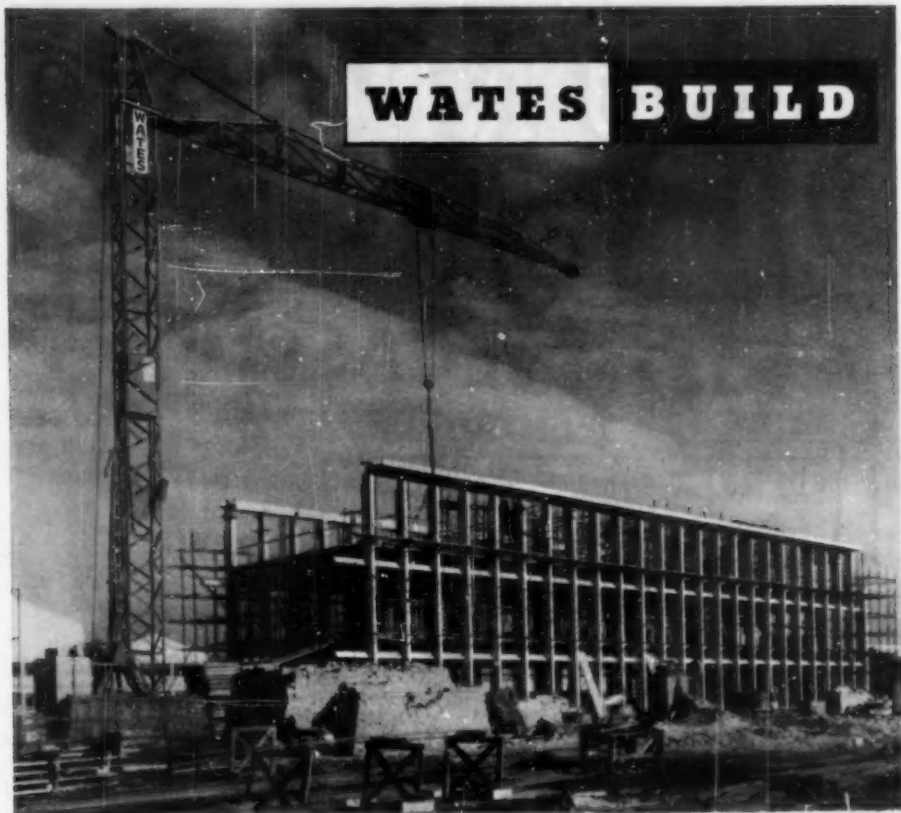
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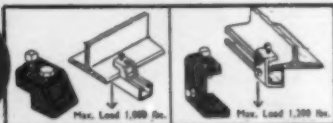
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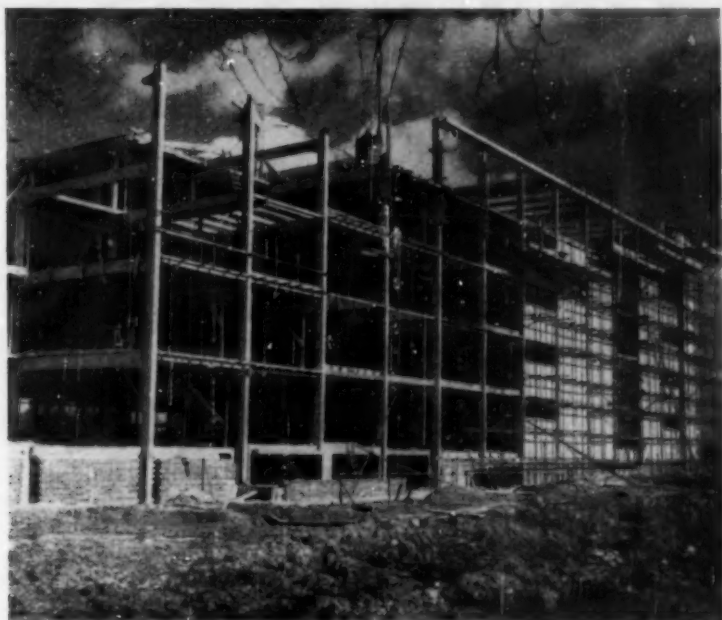
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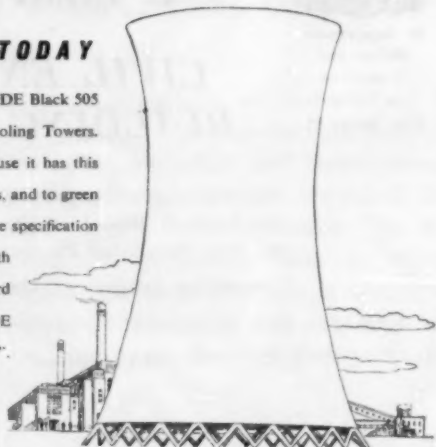
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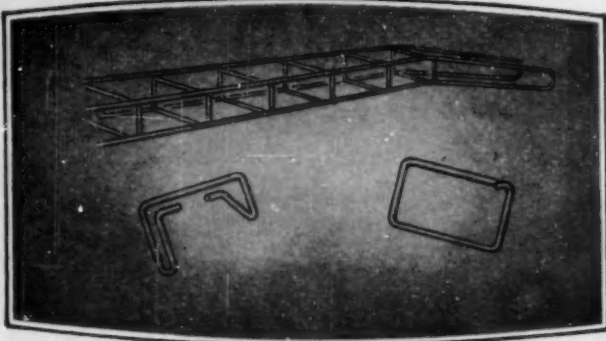


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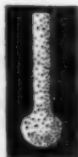
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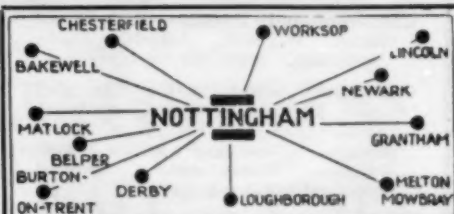
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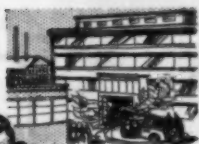
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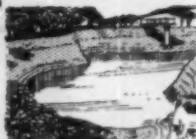
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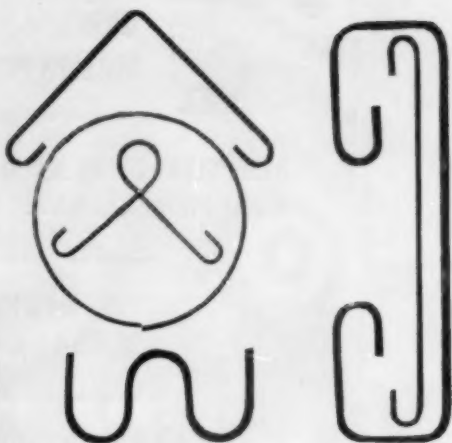
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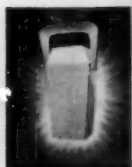
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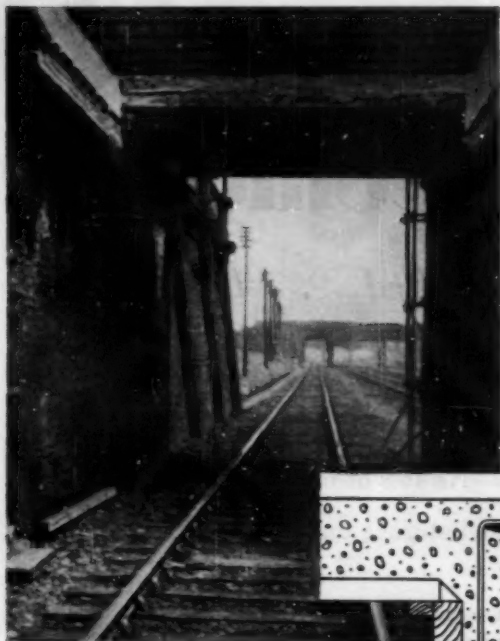
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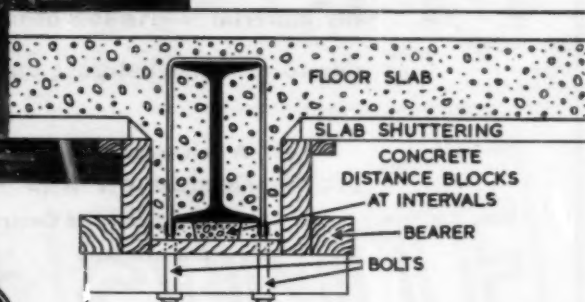
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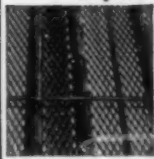
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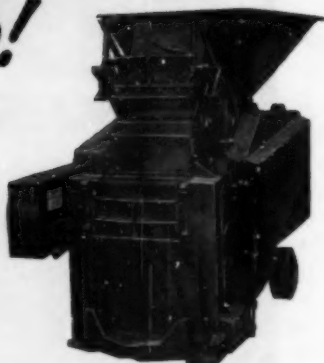


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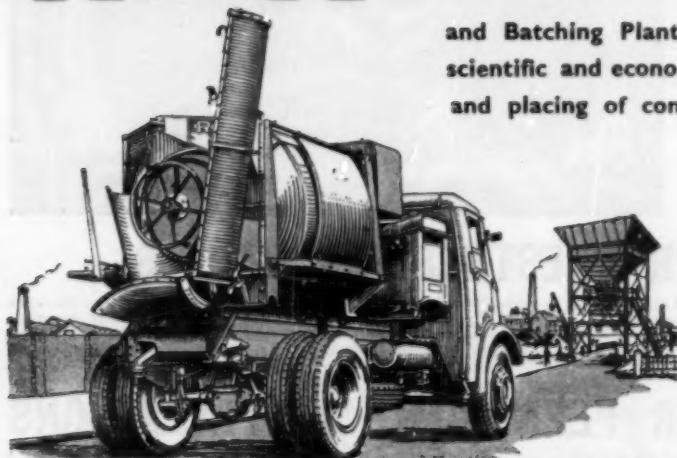
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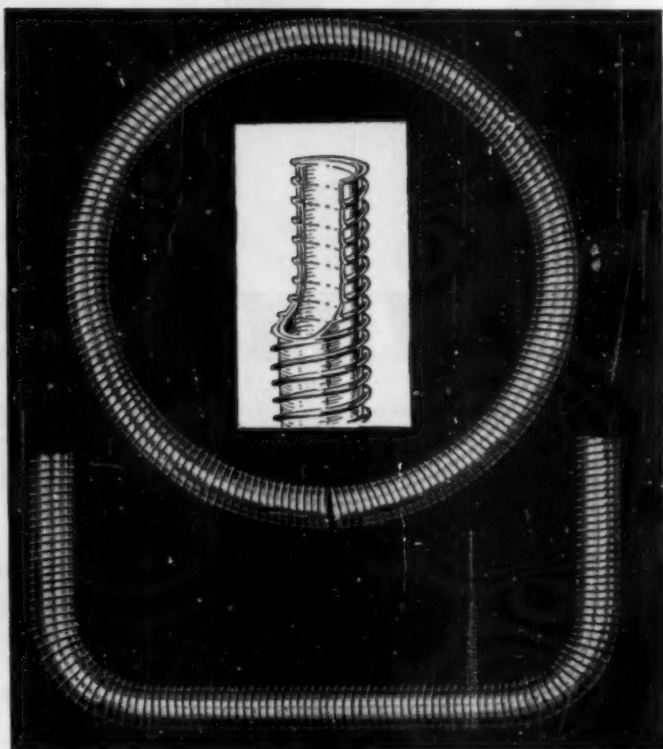
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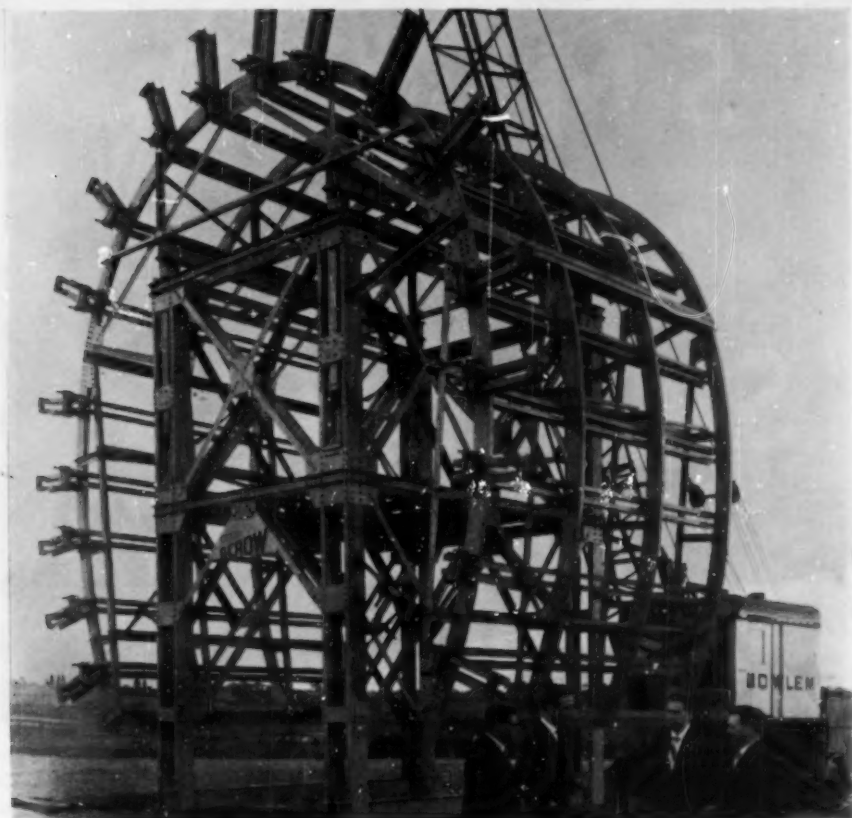
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# CONCRETE AND CONSTRUCTIONAL ENGINEERING

INCLUDING PRESTRESSED CONCRETE

Volume XLIX, No. 12.

LONDON, DECEMBER, 1954.

## EDITORIAL NOTES

### New British Standard for Aggregates.

It is not likely that all engineers will agree that the revision of British Standard No. 882, "Coarse and Fine Aggregates from Natural Sources for Concrete", now issued with No. 1201 ("Aggregates for Granolithic Concrete Floor Finishes"), is an improvement so far as the grading of sand is concerned. The main alteration is in the requirements for sand, and it seems that now a very wide range of sands can be claimed to comply with the standard. Class A and Class B sands of the earlier standard have been replaced by sands in four zones of varying degrees of fineness. The foreword to the standard states that the former classification "tended to brand as inferior a large proportion of the available fine aggregates from which good concrete can be made." It is stated that these new zones comprise gradings in which the fine aggregate becomes progressively finer from zone 1 to zone 4. This is, however, true only so far as the percentage passing the No. 25 sieve and the general trend are concerned. The largest amount that may pass a No. 25 sieve in any zone is 1 per cent. less than the smallest amount allowed to pass the same sieve in the zone immediately above it, while on the other sieves from No. 100 to  $\frac{3}{16}$ -in. there can be overlapping in adjacent zones. The extent of this overlapping and a comparison with the two classes in the previous standard are perhaps best seen by calculating the fineness moduli of the upper and lower limits of size. The fineness moduli of Class A natural sand and crushed gravel sand were 2.2 for the fine limit and 3.6 for the coarse limit, and for stone sand 2.35 and 3.75. In Class B the fineness moduli of the outer limits were 1.45 and 4.10. None of the zones in the new standard corresponds to Class A, but zone 2 is nearest to it. The fineness moduli of the fine and coarse limits of size in the new zones are 2.71 and 4.00 in zone 1, 2.11 and 3.35 in zone 2, 1.71 and 2.75 in zone 3, and 1.35 and 2.25 in zone 4. Sand in zone 4 can contain as much as 10 per cent. more passing a No. 50 sieve than sand in the discarded Class B. These fineness moduli show the extent of the overlapping in adjacent zones, even though no one grading can lie completely in two adjacent zones because of the small (1 per cent.) separations between the zones on the ordinate for the No. 25 sieve. Nevertheless, the fineness moduli enable a comparison to be made with the limits of Class A in the previous standard.

It seems that the purpose of the change is to give equal merit to the gradings in each zone, and so to permit the use of very fine gradings that many engineers

would not use if better were available. Clause 4 (b) no longer suggests that certain extreme gradings are inferior, as it did in the 1944 specification. Nevertheless, it has been necessary to suggest precautions in their use. For example, in the foreword and in a note to Clause 4 (b) it is stated that the ratio of coarse to fine aggregate should be increased as the sand becomes finer, that proportioning becomes more important as the grading of the sand approaches the outer limits of zones 1 and 4, and that sand in zone 4 should not be used in reinforced concrete unless tests are made to ascertain the suitability of the mixture. Those who prefer sands of medium fineness moduli and reject sand containing a high proportion of one size will disagree with the suggestion in the standard that sands (a) with a fineness modulus of 1.35 and containing 50 per cent. of one size and (b) with a fineness modulus of 1.85 and containing 85 per cent. between No. 25 and No. 52 sieves are equal in value in concrete making to a uniformly-graded sand with a fineness modulus of, say, 2.6.

The Institution has issued an explanatory statement which suggests that the zones are related to the sands available in different parts of the country. It is pointed out that in some districts only very fine or very coarse sands are available at a reasonable cost and that these must be used. It seems, therefore, that this part of the standard is less a standard of good concrete making than a standard of expediency for making use of materials that would otherwise be rejected by many engineers. Only in a footnote is it stated that sands in zone 4 should not be used in reinforced concrete unless tests have been made to ascertain the suitability of the proposed mixture. This warning might well have gone farther by stating that it is not so easy to make good concrete with some of the sands in zones 1 and 4 as it is with uniformly-graded sands of medium fineness, and emphasising the risk of segregation in concretes having a slump of about 3 in. made with fine sand and coarse aggregate retained on a  $\frac{3}{16}$ -in. sieve. The footnote to Clause 4 (b) might well be printed in larger and bolder type to avoid the risk of the inexperienced having a false confidence in sands with a preponderance of very fine or very coarse particles. The division of sand into two classes in the previous standard had the special merit of drawing attention to the difference between sands of medium size and sands of extreme fineness or extreme coarseness. It is not now sufficient to specify that fine aggregate should comply with requirements of B.S. No. 882 : 1954, Clause 4b (1). It is desirable to determine beforehand the types of sand available within reach of the work, and it is necessary to add restrictive clauses on the grading and proportioning of the coarse aggregates. No doubt test results can be produced to prove that dense and strong concrete can be made with extremely fine and extremely coarse sands, but more care is needed in choosing the proportions of such mixtures and in preventing segregation during transport and placing.

The other changes in B.S. No. 882 are improvements. The limiting gradings for all-in aggregate have been restricted by introducing limits for the No. 25 sieve size. The limit for clay, silt, and fine dust in natural sand or crushed gravel sand is decreased from 4 per cent. to 3 per cent.

# Analysis of an Arch Frame with Two Bays on Columns with Fixed Bases.

By V. A. MORGAN, M.Eng., A.M.I.C.E.

As is assumed in previous articles by the writer,<sup>(1)</sup> the moment of inertia of an arch rib varies from crown to springing in the ratio  $I_0$  to  $I_0 \sec \theta$ , where  $I_0$  is the moment of inertia at the crown. In order to develop for a one-story frame with two bays the analysis previously given for a single frame of one story, the same symbols as in the previous article are used, namely,  $L$  = span centre to centre of columns;  $h$  ( $=L$ ) = height of columns;  $r$  = rise of arch ( $\frac{L}{2}$ ). Columns BA and  $B_1A_1$  are assumed to have a moment of inertia twice that at the

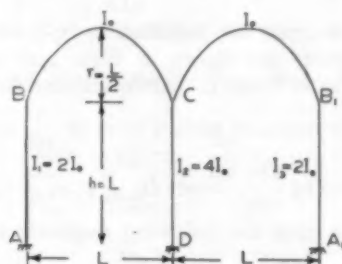


Fig. 1.

crown of the arch and the central column CD a moment of inertia four times that at the crown (Fig. 1). The stiffness-ratios are : At the springings,  $\frac{9EI_0}{L}$ ; columns AB and  $A_1B_1$  (assumed to be fixed at their bases),  $\frac{4EI_1}{L} = \frac{8EI_0}{L}$ ; column CD,  $\frac{4EI_2}{L} = \frac{16EI_0}{L}$ . Thus the moment-distribution ratios at B and  $B_1$  are as 9 is to 8, and at C as 9 is to 16. The carry-over factor is  $-\frac{1}{3}$ , as shown in the previous articles.

## Horizontal Load at Springings B and C.

Due to the deflection  $\Delta_1$  at B the fixed-end moments  $c_1$  at the top and bottom of column AB are  $\frac{6I_1\Delta_1E}{h^2} = \frac{12\Delta_1EI_0}{L^2}$ . Similarly at the top and bottom of column  $A_1B_1$  the fixed-end moments  $c_3$  due to  $\Delta_3$  are  $\frac{12\Delta_3EI_0}{L^2}$ , and for the central column CD the fixed-end moments  $c_2$  are  $\frac{6I_2\Delta_2E}{h^2} = \frac{24\Delta_2EI_0}{L^2}$ . The moments at the springings are : At B for arch BC,  $-D_1 = \frac{-15EI_0(\Delta_1 - \Delta_2)}{2Lr}$ ; at C for arch BC,

(1) Analysis of a Parabolic Arch supported by Columns Fixed at their Bases. August and December, 1953.

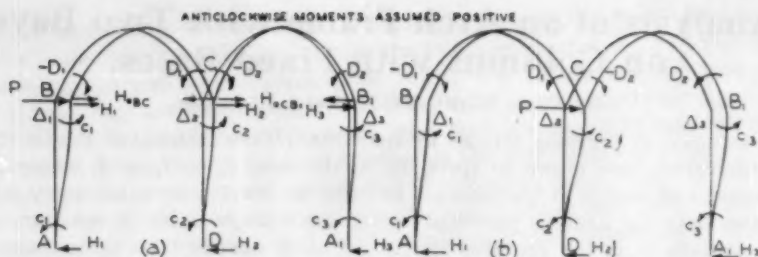


Fig. 2.

+  $D_1$ ; at C for arch  $CB_1$ ,  $-D_2 = -\frac{15EI_0(\Delta_2 - \Delta_3)}{2Lr}$ ; and at  $B_1$  for arch  $CB_1$ , +  $D_2$ . Anti-clockwise moments are assumed to be positive, and the directions of the moments and thrusts are shown in Figs. 2(a) and (b). The fixed-end moments are distributed as in Table I. Alternate distributions of these moments decrease in geometrical progression with a ratio of  $\frac{9}{17^2}$  and their sum to infinity is their first term multiplied by  $\frac{289}{280}$ . Since  $D_1 = \frac{5}{8}(2c_1 - c_2)$ , and  $D_2 = \frac{5}{8}(c_2 - 2c_3)$ , summation and reduction give the following moments in terms of  $c_1$  and  $c_2$ :

$$M_{AB} = \frac{4917c_1 - 697c_2 - 123c_3}{34 \times 140}$$

$$M_{A_1B_1} = \frac{4917c_3 - 697c_2 - 123c_1}{34 \times 140}$$

$$M_{BA} = \frac{2537c_1 - 697c_2 - 123c_3}{17 \times 140}$$

$$M_{B_1A_1} = \frac{2537c_3 - 697c_2 - 123c_1}{17 \times 140}$$

$$M_{CB} = \frac{2132c_1 - 1207c_2 - 738c_3}{17 \times 140}$$

$$M_{CB_1} = \frac{2132c_3 - 1207c_2 - 738c_1}{17 \times 140}$$

$$M_{CD} = \frac{71c_2 - 41c_1 - 41c_3}{70}$$

$$M_{DC} = \frac{141c_2 - 41c_1 - 41c_3}{140}$$

These moments may be written in a more useful form thus:

$$\left. \begin{matrix} M_{AB} \\ M_{A_1B_1} \end{matrix} \right\} = \frac{141c_1 - 41c_2 + 141c_3}{280} \pm \frac{9}{17}(c_1 - c_3) \quad (1)$$

$$\left. \begin{matrix} M_{BA} \\ M_{B_1A_1} \end{matrix} \right\} = \frac{71c_1 - 41c_2 + 71c_3}{140} \pm \frac{19}{34}(c_1 - c_3) \quad (2)$$

$$\left. \begin{matrix} M_{CB} \\ M_{CB_1} \end{matrix} \right\} = \frac{41c_1 - 71c_2 + 41c_3}{140} \pm \frac{41}{68}(c_1 - c_3) \quad (3)$$

Also  $H_1 = \frac{M_{AB} + M_{BA}}{L}$

$$\left. \begin{matrix} H_1 \\ H_3 \end{matrix} \right\} = \frac{283c_1 - 123c_2 + 283c_3}{280L} \pm \frac{37}{34L}(c_1 - c_3) \quad (4)$$

$$H_2 = \frac{283c_2 - 123c_1 - 123c_3}{140L} \quad (5)$$

The thrust for the pin-jointed condition of arch BC is

$$H_{0BC} = -\frac{15EI_0}{2L^3}(A_1 - A_2) = -\frac{5}{16L}(2c_1 - c_2),$$

where the negative sign denotes an inward thrust.

Similarly  $H_{0CB_1} = -\frac{5}{16L}(c_2 - 2c_3)$ . Since  $H_{BC} = H_{0BC} + \frac{5}{8r}(M_{BC} - M_{CB})$ ,

then 
$$H_{BC} = \frac{21c_2 - 21c_1 - 21c_3}{16L} - \frac{30}{17L}(c_1 - c_3),$$

and 
$$H_{CB_1} = \frac{21}{16L}(c_1 - c_2 + c_3) - \frac{30}{17L}(c_1 - c_3).$$

As the negative sign denotes only inward thrust, the actual values are

$$\left. \begin{matrix} H_{BC} \\ H_{CB_1} \end{matrix} \right\} = \left[ \pm \frac{21}{16L}(c_1 - c_2 + c_3) + \frac{30}{17L}(c_1 - c_3) \right] \quad (6)$$

HORIZONTAL LOAD AT SPRINGING B [Fig. 2(a)].—At springing B,  $H_3$  must equal  $H_{CB_1}$ , so that

$$\frac{283c_1 - 123c_2 + 283c_3}{280L} - \frac{37}{34L}(c_1 - c_3) = -\frac{21}{16L}(c_1 - c_2 + c_3) + \frac{30}{17L}(c_1 - c_3) \quad (7)$$

Similarly  $H_{BC} - H_{CB_1} = H_2$ , so that

$$\frac{714(c_1 - c_2 - c_3)}{16 \times 17} = \frac{283c_2 - 123c_1 - 123c_3}{140} \quad (8)$$

and 
$$c_1 + c_3 = \frac{1301}{981}c_2 \quad (9)$$

Reducing (7) and substituting for  $c_1$  and  $c_3$ ,  $c_1 = \frac{170,533}{190,314}c_2$  and  $c_3 = \frac{81,861}{190,314}c_2$ ;

also  $P = H_1 + H_2 + H_3$ . Thus, substituting for  $H_1$ , etc.,

$$P = \frac{8}{7L}(c_1 + c_2 + c_3), \quad c_1 = \frac{170,533}{505,952}PL, \quad c_3 = \frac{81,861}{505,952}PL, \quad \text{and} \quad c_2 = \frac{981}{2608}PL.$$

By inserting these values the equations for the moments and the thrusts become

$$\left. \begin{matrix} M_{CB} \\ M_{CB_1} \end{matrix} \right\} = PL \left( \frac{-233}{5216} \pm \frac{41}{388} \right), \quad \left. \begin{matrix} M_{BA} \\ M_{BA_1} \end{matrix} \right\} = PL \left( \frac{745}{5216} \pm \frac{38}{388} \right),$$

$$\left. \begin{matrix} M_{AB} \\ M_{A_1B_1} \end{matrix} \right\} = PL \left( \frac{1023}{5216} \pm \frac{36}{388} \right), \quad M_{CD} = \frac{233}{2608}PL, \quad M_{DC} = \frac{607}{2608}PL,$$

$$H_2 = \frac{105}{326}P, \quad \left. \begin{matrix} H_1 \\ H_3 \end{matrix} \right\} = \frac{221}{652}P \pm \frac{37}{194}P.$$

These values are shown in Fig. 3(a).

TABLE I.

A	$\frac{1}{2}$	B B 9	$-\frac{1}{2}$	C C 16	$\frac{1}{2}$	D D 9	$-\frac{1}{2}$	E E 8	$\frac{1}{2}$	A
$c_1$	$c_1$	$-D_1$	$D_1$	$c_2$	$-D_2$	$D_2$	$c_3$	$-D_3$	$D_3$	$c_3$
$\frac{8}{17}(D_1 - c_1)$	$\frac{9}{17}(D_1 - c_1)$	$\frac{9}{34}(D_1 - c_1)$	$\frac{16}{34}(D_1 - c_1)$	$\frac{9}{34}(D_2 - c_2)$	$\frac{9}{17}(D_2 - c_2)$	$-\frac{9}{17}(D_2 + c_2)$	$-\frac{9}{17}(D_2 + c_2)$	$-\frac{9}{17}(D_2 + c_2)$	$-\frac{9}{17}(D_2 + c_2)$	$c_3$
$\frac{4}{17}(D_1 - c_1)$	$\frac{3}{32}(D_2 - c_2)$	$-\frac{3}{17}(D_2 - c_2)$	$\frac{8}{34}(D_2 - c_2)$	$\frac{3}{17}(D_2 + c_2)$	$-\frac{3}{34}(D_2 - c_2)$	$-\frac{4}{17}(D_2 + c_2)$				
			ETC.							

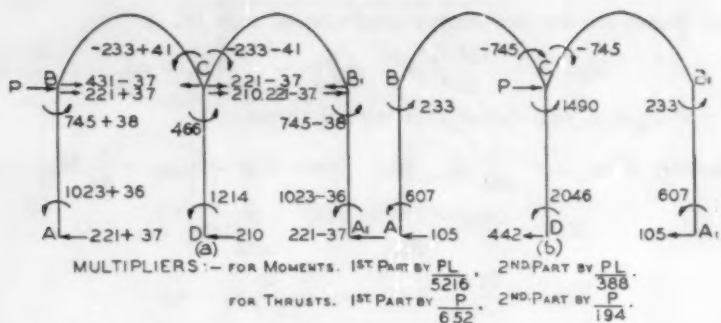


Fig. 3.

HORIZONTAL LOAD AT SPRINGING C [Fig. 2(b)].—For the case in which the moment of inertia  $I_2$  of the central column is twice the moments of inertia  $I_1$  and  $I_3$  of columns AB and CD the bending moments and thrusts are obtained as follows from the moments and thrusts derived for the load  $P$  acting at the springings at B or  $B_1$ . In Fig. 3(a) the variable terms for the moments and thrusts are omitted and the two invariable terms for moments  $M_{CB}$  and  $M_{B_1A_1}$  are added, giving  $M_{CD}$  in Fig. 3(b); similarly  $M_{AB}$  and  $M_{A_1B_1}$  are added to give  $M_{DC}$  in Fig. 3(b), and  $M_{CD}$  and  $M_{DC}$  in Fig. 3(a) are divided by two. Thus  $M_{BA}$ ,  $M_{B_1A_1}$ ,  $M_{AB}$ , and  $M_{A_1B_1}$  in Fig. 3(b) are derived. The thrusts are then obtained by addition of the moments on the columns.  $M_{CB}$  and  $M_{CB_1}$  are minus one-half of  $M_{CD}$ . The reason for this procedure is apparent because the frame comprises two symmetrical frames. For this type of double frame the ratio  $\frac{M_{CD}}{I_2}$  due to  $P$  acting at B [Fig. 3(a)] is equal to  $\frac{M_{BA}}{I_1}$  due to  $P$  acting at C [Fig. 3(b)] and, from Maxwell's Theorem, the deflection  $\Delta_{2B}$  due to  $P$  acting at B must equal the deflection  $\Delta_{1C}$  at B due to  $P$  acting at C. Therefore in a series of frames comprising symmetrical single frames the ratios  $\frac{M}{I}$  for the end columns and the internal columns for the two cases shown in Figs. 3(a) and (b) are equal. For frames comprising two single frames whose columns have unequal moments of inertia the ratio  $\frac{M_{CD}}{I_2}$  for  $P$  acting at B is not equal to  $\frac{M_{BA}}{I_1}$  for  $P$  acting at C, and the general solution given later should be used. For all frames, however, Maxwell's Theorem applies and can be used as a partial check, as  $\Delta_{2B}$  is proportional to  $\frac{c_2}{I_2}$  for load  $P$  at B and  $\Delta_{1C}$  is proportional to  $\frac{c_1}{I_1}$  for  $P$  at C (where  $c_2$  and  $c_1$  are the fixed-end moments on the columns at C and B), so that in all frames  $\frac{c_{2B}}{I_2}$  must equal  $\frac{c_{1C}}{I_1}$ . For the particular solutions given here  $c_{2B} = \frac{981}{2608}PL$  and (see later)  $c_{1C} = \frac{981}{5216}PL$ . As  $I_2 = 2I_1$ , the ratios previously mentioned are equal. With these ratios determined, the moments and thrusts due to all arrangements of loads on the frame, symmetrical or otherwise, can be calculated.

### Uniform Vertical Load.

The frame and the arrangement of the loads are shown in *Fig. 4*. A uniformly-distributed load acting on a parabolic arch does not cause bending, and at the springings there are no fixing moments but only vertical reactions and horizontal thrusts  $P_1$  acting inwards. The thrusts can be calculated by equating the moment due to  $P_1$  to the moment due to the uniform load, both calculated about the crown of the arch.

$$\text{Thus } P_1 r = P_1 \frac{L}{2} = \frac{wL^2}{8}, \text{ and } P_1 = \frac{wL}{4}.$$

The restraint at springing B is removed by applying the components of  $P_1$ , acting on the arch and the top of the column, due to the action of the frame (*Fig. 3a*). The component due to the arch reduces the inward thrust  $P_1$  to  $P_1 - \left(\frac{431}{652} - \frac{37}{194}\right) P_1 = \left(\frac{221}{652} + \frac{37}{194}\right) P_1$ , whilst the component at the top of the column is unaltered and is of the same value as that due to the arch but acts in the opposite direction, thus keeping the springing in equilibrium. At Springing B<sub>1</sub>, the thrust  $P_1$  acting at B causes an outward thrust of  $\left(\frac{221}{652} - \frac{37}{194}\right) P_1$  on the arch, and an equal thrust, but in the opposite direction, on the top of the column. When springing B<sub>1</sub> is unrestrained thrusts of the same value but of opposite sign are produced at B and B<sub>1</sub>.

$$\text{Then } H_{1B(\text{arch})} = \left(\frac{221}{652} + \frac{37}{194}\right) P_1 - \left(\frac{221}{652} - \frac{37}{194}\right) P_1 = \frac{37}{97} P_1 = \frac{37}{388} wL.$$

$H_{1B(\text{column top})}$  has the same value but is of opposite sign.

$$M_{BA} = -\left(\frac{745}{5216} + \frac{38}{388}\right) P_1 L + \left(\frac{745}{5216} - \frac{38}{388}\right) P_1 L = \frac{-19wL^2}{388} = -M_{B_1A_1}.$$

$$M_{AB} = -\left(\frac{1023}{5216} + \frac{36}{388}\right) P_1 L + \left(\frac{1023}{5216} - \frac{36}{388}\right) P_1 L = \frac{-18wL^2}{388} = -M_{A_1B_1}.$$

$$M_{CB} = \left(\frac{233}{5216} - \frac{41}{388}\right) P_1 L - \left(\frac{233}{5216} + \frac{41}{388}\right) P_1 L = \frac{-41wL^2}{776} = -M_{CB_1}.$$

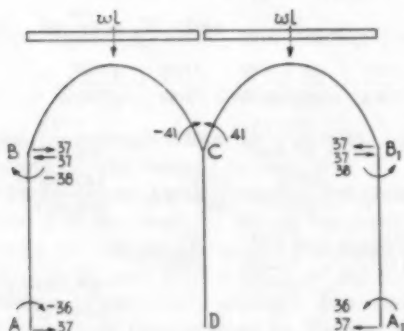


Fig. 4.

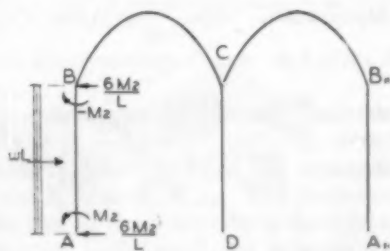


Fig. 5.

TABLE 2.

A.	$\frac{1}{2}$	8 B 9	$-\frac{1}{3}$	9 C 16	$\frac{1}{2}$	16 C 9	$-\frac{1}{3}$	9 B 8	$\frac{1}{2}$	A.
$M_2$		$-M_2$								
		$\frac{8M_2}{17}$	$\frac{9M_2}{17}$ ETC.							
TOTALS -										
2949 $M_2$		-621 $M_2$	621 $M_2$	-156 $M_2$	6 $M_2$	3 $M_2$	54 $M_2$	-9 $M_2$	9 $M_2$	9 $M_2$
2380		1190	1190	1190	70	70	1190	1190	1190	2380

These moments and thrusts are immediately derived from Fig. 3(a) for components of  $P_1$  acting outwards, at B and  $B_1$ . Fig. 4 shows the final moments and thrusts: the multipliers for the moments and thrusts being  $\frac{wL^2}{776}$  and  $\frac{wL}{388}$  respectively. The reaction at the crown and other necessary data can now be calculated by statics.

### Uniform Side Load.

For the frame acted upon by the load shown in Fig. 5 the fixed-end moments  $M_2$  are  $\frac{wL^2}{12}$ . The thrusts, obtained from the summations of the moments distributed in Table 2, are:

$$H_{1A} = \frac{1707M_2}{2380L}, H_2 = \frac{9M_2}{70L}, H_3 = \frac{27M_2}{2380L}, H_{arch BC} = \frac{555M_2}{680L}, \text{ and } H_{arch B_1C} = \frac{45M_2}{680L}.$$

$$P_B = \text{unbalanced force at B} = \left( \frac{3885}{4760} - \frac{3414}{4760} + 6 \right) \frac{M_2}{L} = \frac{471 M_2}{4760L} + 6 \frac{M_2}{L}.$$

$$P_C = \text{unbalanced force at C} = \left( \frac{3885}{4760} - \frac{315}{4760} + \frac{612}{4760} \right) \frac{M_2}{L} = \frac{4182 M_2}{4760L}.$$

$$P_{B_1} = \left( \frac{315 + 54}{4760} \right) \frac{M_2}{L} = \frac{369 M_2}{4760L}.$$

Then the final thrusts and moments are:

$$\begin{aligned} \frac{H_{1A}L}{M_2} &= 6 + \frac{1707}{2380} + \left( \frac{221}{652} + \frac{37}{194} \right) \left( \frac{471}{4760} + 6 \right) - \left( \frac{221}{652} - \frac{37}{194} \right) \frac{369}{4760} - \left( \frac{105}{652} \times \frac{4182}{4760} \right) \\ &= \frac{309,729}{31,622}, \text{ and } H_{1A} = \frac{103,243}{126,488} wL. \end{aligned}$$

$$\begin{aligned} \frac{H_2L}{M_2} &= \frac{9}{70} + \frac{210}{652} \left( \frac{471}{4760} + 6 \right) - \left( \frac{210}{652} \times \frac{369}{4760} \right) - \left( \frac{442}{652} \times \frac{4182}{4760} \right) = \frac{46,560}{31,622}, \\ &\text{and } H_2 = \frac{20}{163} wL. \end{aligned}$$

$$\begin{aligned} \frac{H_3L}{M_2} &= \frac{27}{2380} + \left( \frac{221}{652} - \frac{37}{194} \right) \left( \frac{471}{4760} + 6 \right) - \left( \frac{221}{652} + \frac{37}{194} \right) \frac{369}{4760} - \left( \frac{105}{652} \times \frac{4182}{4760} \right) \\ &= \frac{23,175}{31,622}, \text{ and } H_3 = \frac{7725}{126,488} wL. \end{aligned}$$

$$M_A = \frac{2949}{2380} L + \left( \frac{1023}{5216} + \frac{36}{388} \right) P_B L - \frac{607}{5216} P_C L - \left( \frac{1023}{5216} - \frac{36}{388} \right) P_{B_1} L = \frac{121,887}{505,952} wL^2.$$

$$\begin{aligned} M_B &= -\frac{621}{1190} L + \left( \frac{745}{5216} + \frac{38}{388} \right) P_B L - \frac{233}{5216} P_C L - \left( \frac{745}{5216} - \frac{38}{388} \right) P_{B_1} L \\ &= \frac{38,109}{505,952} wL^2. \end{aligned}$$

$$M_{CD} = \frac{6}{70} L, \text{ etc.} = \frac{7857}{252,976} wL^2, M_{DC} = \frac{23,183}{252,976} wL^2.$$

$$M_{CB} = \frac{15,941}{505,952} wL^2, \quad M_{CB_1} = -\frac{31,655}{505,952} wL^2.$$

$$M_{A_1} = \frac{21,479}{505,952} wL^2, \quad M_{B_1} = \frac{9421}{505,952} wL^2.$$

As a check  $\Sigma M_{(column)} = \frac{wL^2}{2}$ , and  $\Sigma H = wL$ .

### General Method of Extending the Solution for a Single Frame to a Frame with Two Bays.

This method applies to any ratio of  $I_2$  to  $I_1$  ( $= I_3$ ), that is the ratio of the moment of inertia of the central column to that of the side columns. The first parts of equations (1) to (6) can be obtained from the equations for the moments, etc., derived in the article for the single frame<sup>(1)</sup> by simply adding a term for  $c_3$  with a coefficient which makes the equations symmetrical and then, except for the equations for the central column, dividing the equations by two as follows:

FIRST PART OF EQUATION  
FOR SINGLE-BAY FRAMES.

FIRST PART OF EQUATION FOR  
DOUBLE-BAY FRAMES.

$$M_{BA} = \frac{71c_1 - 41c_2}{70} \quad \frac{71c_1 - 41c_2 + 71c_3}{140} = M_{BA} \text{ and } M_{B_1A_1} \quad (2a)$$

$$M_{AB} = \frac{141c_1 - 41c_2}{140} \quad \frac{141c_1 - 41c_2 + 141c_3}{280} = M_{AB} \text{ and } M_{A_1B_1} \quad (1a)$$

$$M_{DC} = \frac{141c_2 - 41c_1}{140} \quad \frac{141c_2 - 41c_1 - 41c_3}{140} = M_{DC},$$

$$M_{CB} = \frac{41c_1 - 71c_2}{70} \quad \frac{41c_1 - 71c_2 + 41c_3}{140} = M_{CB} \text{ and } M_{CB_1} \quad (3a)$$

$$M_{CD} = \frac{71c_2 - 41c_1}{70} \quad \frac{71c_2 - 41c_1 - 41c_3}{70} = M_{CD},$$

$$H_2 = \frac{283c_2 - 123c_1}{140L} \quad \frac{283c_2 - 123c_1 - 123c_3}{140L} = H_2,$$

$$H_1 = \frac{283c_1 - 123c_2}{140L} \quad \frac{283c_1 - 123c_2 + 283c_3}{280L} = H_1 \text{ and } H_3 \quad (4a)$$

$$H_{arch} = \frac{21}{8L}(c_1 - c_2) \quad \left. \begin{matrix} H_{BC} \\ H_{CB_1} \end{matrix} \right\} = \pm \frac{21}{16L}(c_1 - c_2 + c_3) \quad (6a)$$

Equating  $H_{CB_1}$  to  $H_3$  and solving for  $c_1$ ,  $c_2$ , and  $c_3$ ,  $c_1 = c_3 = \frac{981}{2602}c_2$ . Also

$H_1 + H_2 + H_3 = P$ , so that  $c_1 = c_3 = \frac{981}{5216}PL$  and  $c_2 = \frac{1301}{2608}PL$ . The moments and thrusts are shown in Fig. 3(b). This is the symmetrical case and gives  $P$  acting at the central springing.

To obtain the distribution of moments and thrusts for the unsymmetrical case it is necessary to obtain the coefficients of  $(c_1 - c_3)$  which form the second parts of the equations for the double frame, and then solve the equations  $H_{CB_1} = H_3$  and  $H_{BC} = (H_{CB_1} - H_2)$  for  $c_1$  and  $c_3$  in terms of  $c_2$ . The procedure is then as previously shown. The coefficients of  $(c_1 - c_3)$  may be derived from the moment distributions in Table 1. Assuming that  $I_1 = I_3$  for columns AB and  $A_1B_1$ , the general expressions for the coefficients in terms of  $u$  and  $v$  (the

ratios at the springings of the stiffness of the fixed-end column to that of the arch) for a variable rise  $r$  of the arch, are as follows where  $f = \frac{I_0 h^2}{I_1 L r}$ :

$$\begin{aligned} \left. \begin{aligned} M_{AB} \\ M_{A,B_1} \end{aligned} \right\} &= \pm \frac{8v + 4u + 5fu}{16(u+v)} & \left. \begin{aligned} M_{BA} \\ M_{B,A} \end{aligned} \right\} &= \pm \frac{4v + 5fu}{8(u+v)} \\ \left. \begin{aligned} M_{CB} \\ M_{C,B_1} \end{aligned} \right\} &= \pm \frac{4v + 5f(2v + 3u)}{24(u+v)} \\ \left. \begin{aligned} H_1 \\ H_3 \end{aligned} \right\} &= \pm \frac{16v + 4u + 15fu}{16h(u+v)} \\ \left. \begin{aligned} H_{BC} \\ H_{CB} \end{aligned} \right\} &= \pm \frac{20v + 5f(4v + 9u)}{48r(u+v)} \end{aligned}$$

Substituting in these expressions  $u = 8$ ,  $v = 9$ ,  $h = L$ ,  $I_1 = 2I_0$ ,  $r = \frac{L}{2}$ , multiplying by  $(c_1 - c_3)$ , and adding to the first part of the equations already derived, equations (1) to (6) are obtained. The solution of equations (7) and (8) and the equations for the moment and thrust in terms of  $P$  is as previously explained. The general expressions for the second part of the equations are useful as the first part can be obtained from the solution by moment distribution of the single frame, and the combined equations are then solved for  $c_1$  and  $c_3$  in terms of  $c_2$ , etc. When all these values are obtained, the moments on the rib and the reactions may be obtained by statics.

#### Frames with Columns Hinged at the Bases.

The analysis of frames with columns free to rotate at their bases is the same as that when the columns are fixed at their bases, and it is necessary to calculate the horizontal thrusts acting at the springings on the end and central columns due to the unbalanced forces and moments caused by the loads. The stiffness ratio of columns with hinged bases will be three-quarters of that of columns with fixed bases. Thus the ratio of the stiffness of the arch to that of the column will be as 9 is to 6 for the external columns, and for the central column the ratio between the arch, the column, and the adjoining arch will be as 9:12:9. Also, since  $c_1$ ,  $c_2$ , and  $c_3$  are equal to  $\frac{3A_1EI_1}{h^2}$ ,  $\frac{3A_2EI_2}{h^2}$ , and  $\frac{3A_3EI_1}{h^2}$ , the values of  $D_1$ ,  $D_2$ ,  $H_{0BC}$  and  $H_{0B,F_1}$  must be altered by substituting for  $A_1$ , etc., in terms of  $c_1$ ,  $c_2$ , and  $c_3$ . Thus

$$H_{0BC} = -\frac{5h^2I_0}{8r^2L} \left( \frac{c_1}{I_1} - \frac{c_2}{I_2} \right) \quad \text{and} \quad D_1 = \frac{5h^2I_0}{2rL} \left( \frac{c_1}{I_1} - \frac{c_2}{I_2} \right).$$

## A Prestressed Factory for Heavy Machinery.

THE factory shown in *Fig. 2*, at Le Havre, France, is about 170 ft. long by 74 ft. wide, and the first floor, carrying machine-tools weighing up to 10 tons each, is designed for an imposed load of 410 lb. per square foot. The following description is abstracted from the Belgian journal "La Technique de Travaux" for November-December, 1953.

### The First Floor.

The first floor is supported by 24 columns in four rows of six columns. In a longitudinal direction the columns are at about 32 ft. centres and in a transverse direction at about 23 ft., 27 ft. 6 in., and 23 ft. centres (*Fig. 2*). The floor consists of main beams (P, Q, R, and M, N in

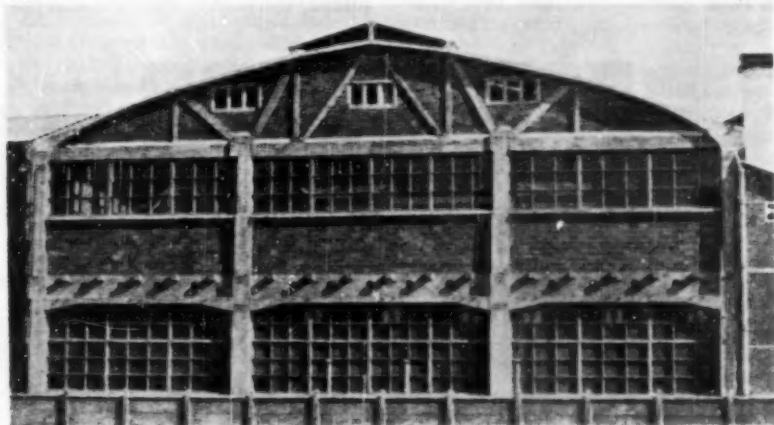


Fig. 1.—End Wall.

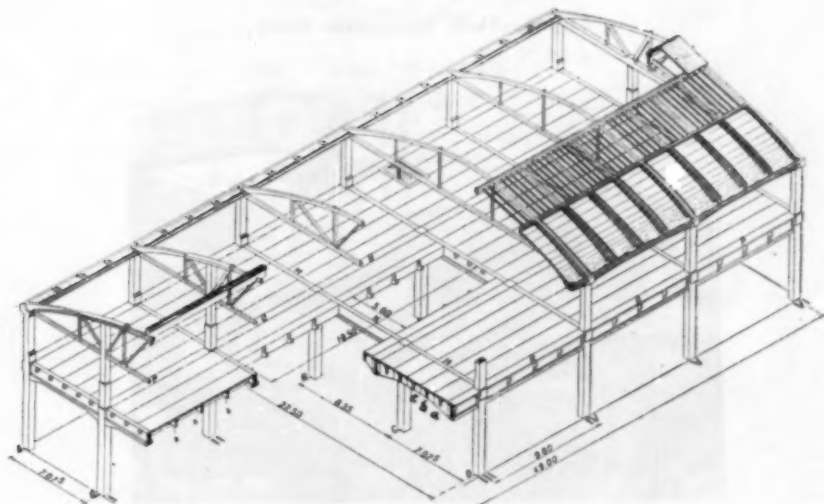


Fig. 2.—Axonometric View of the Factory.

Fig. 2) in two directions on the centre-lines of the columns, the slab being formed by the upper flanges of the longitudinal secondary beams a, b, c, and the transverse secondary beams k, h. All the beams and columns were precast. There are 18 beams M and N (Fig. 3) of which the cross section is an inverted tee, 20 I-shaped beams P, Q, R, and 76 beams a, b, c (Fig. 4) with a tee-shaped cross section. Beams k, h are formed by diaphragms cast with beams a, b, c, and P, Q, R.

All the columns and beams were precast on the ground, the beams being prestressed sufficiently to resist the stresses due to handling, and erected by a mobile crane. The main beams were temporarily supported on steel angles bolted to the tops of the columns; the joints between the beams and the columns were then concreted and the beams prestressed by cables passing through holes in the beams and anchored on the outer face of each column. The secondary beams were then placed, the joints concreted, and the floor

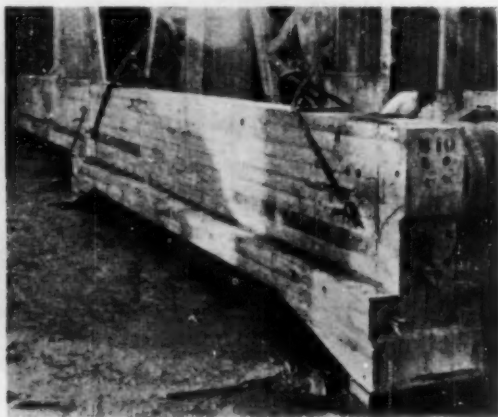


Fig. 3.—Main Transverse Beam.

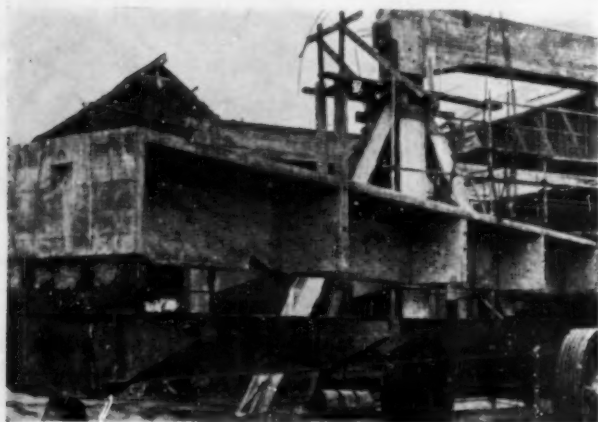


Fig. 4.—Secondary Beam.

prestressed in two directions by cables passing through holes in the beams. In this manner the floor was made continuous in two directions.

### Roof.

The roof (Fig. 2) comprises six tied arches supported on the outer columns and carrying, adjacent to the columns, a curved slab  $2\frac{1}{2}$  in. thick by 16 ft. wide and extending the length of the building. In the centre of the roof is a hipped slab supported centrally on a ridge-beam and at the edges on precast purlins. Between the purlins and the curved slabs are roof-lights on each side of the building. The arches at the ends of the building and one penultimate arch are supported also by intermediate columns (Fig. 1). In addition

to the usual roof loads the arches carry a moving load of 8 tons due to a hoist suspended from the ridge-beam. Other lifting gear is attached to the heads of the columns.

Between the columns is a gutter-beam which was cast in situ with the columns and prestressed. The arches were precast on the ground, except for the prestressed ties which were concreted after the arches were erected. The curved slabs were designed as "shells", and were cast in situ and prestressed; there are three intermediate transverse beams in each bay.

The factory was designed by the Société Technique pour l'Utilisation de la Précontrainte for the Société des Forges et Chantiers de la Méditerranée. The contractors were Entreprise Camus.

### New Rail-clamp for Concrete Sleepers.

A NEW fastening for securing flat-bottom rails to concrete sleepers which, it is hoped, will make travel smoother, prolong the life of the sleepers and help to check creeping of the rail, has been designed by British Railways. The fastening (Fig. 1) consists of two steel clamps which are secured into wooden plugs in the sleeper

and grip the bottom of the rail on each side. Rubber pads between the clamps and the rail and the sleeper absorb vibration and also provide electrical insulation of the rails. If these clamps prove successful in service, it is believed that they may result in an extension of the use of concrete sleepers on main lines.

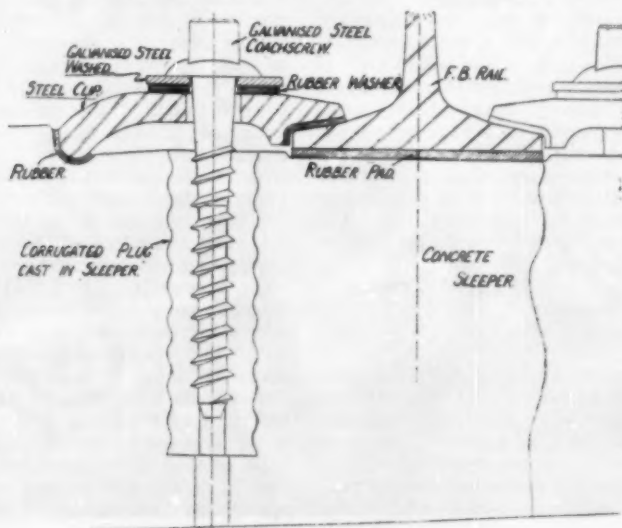


Fig. 1.

## Correspondence.

## THE ENGINEER IN SOCIETY.

SIR,—My attention has been drawn to the Editorial Note in your issue of October, 1954. While not wishing to comment one way or the other on the views expressed therein, I feel I must complain of the highly tendentious manner in which you have used certain quotations from a recent issue of the *Journal of the Engineers' Guild*.

In the context of your remarks, any reader would be justified in assuming that these quotations represent a considered policy on the part of the Guild, whereas reference to the relevant issue will show that in every case they are either a factual report of a statement made by some other person, not necessarily even a member of the Guild, or an excerpt from a letter by a correspondent. An example is your ridicule of the statement that "engineering was the earliest of the arts", which is in fact a quotation by a correspondent from a published encyclopædia. Moreover, your concluding sentence, "It must be unique in history for the members of one profession (other than politicians) to claim that they are best fitted to control the affairs of the world", suggests an implication which is quite fallacious so far as this Guild is concerned.

I need hardly say that the Engineers' Guild is fully prepared to meet legitimate criticism of its policies and attitudes. It objects strongly to allegations, however implied or indirect, which, being based upon faulty premises, misrepresent those policies and attitudes.

In view of the harm which may accrue to the Guild's reputation from your failure to quote the *Journal* correctly, I feel it is reasonable to ask that you should publish some clarification.

J. H. W. TURNER.

Honorary Secretary,  
Engineers' Guild, Ltd.

[The article referred to did not in any way intend to imply that the extracts from the *Journal* of the Guild were the views of the Guild as a body. The view that the cream of the youth of to-day was not attracted to the engineering profession was attributed to a Member of the

Council and Chairman of the Executive Committee in an address at a meeting of a branch of the Guild. The quotation about engineering being the earliest of the arts was in a letter from a member. The views on the role of engineers in politics were reported in an abstract of an address at a congress held in Rome which the Guild considered worthy of publication.

Each number of the *Journal* points out that the Guild does not necessarily agree with the views expressed by its members and reported in its columns, and Mr. Turner's letter makes this very clear indeed. But the Guild is not compelled to go out of its way to publish remarks that make the profession appear to be boastful and ridiculous, as, for example, in reporting a Continental engineer as saying that "the engineer is predestined and prepared to render particularly valuable co-operation in resolving international political questions". The profession will continue to be judged by its works rather than by its political activities.

The writer has had experience in revising encyclopædias, and can assure Mr. Turner and the writer of the letter published in the *Journal* that all the statements and opinions in encyclopædias cannot be accepted as the truth. In the case of the quotation in question, a little thought will show that the guess of the compiler about "the earliest of the arts emerging in the first dawn of civilisation" is not likely to be true.

At the head of the Correspondence pages of the *Journal* of the Guild appears the following quotation from Voltaire: "I may disagree with every word you say; but I will fight to the death for your right to say it." It appears from Mr. Turner's penultimate paragraph that this is another pronouncement in its *Journal* with which the Guild does not necessarily agree—although why Voltaire, or anyone else, should be willing to die to uphold the right of a man to give utterance to any nonsense that enters his head is perhaps beyond the comprehension of most people. Or is this quotation misleading apart from its context?—E.D.]

## Buildings at Renfrew Airport.

THE old terminal buildings at Renfrew airport had for a considerable time been below present-day standards for airfields, and in 1952 the Ministry of Civil Aviation authorised expenditure on a limited scheme for their replacement. Work commenced in April, 1953, and was completed in September 1954. The new buildings, all of which have reinforced concrete frames, consist of a passengers' building, a meteorological and operations building, a control tower, and a small building for the use of the staff of British European Airways. *Fig. 1* shows the general arrangement of the airport. The two major buildings are described in the following.

### Passengers' Building.

The main building, which is for the use of passengers, includes a customs hall, waiting rooms, kitchens, dining room, buffet, and bar. A cross section through the roof over the main concourse (*Fig. 3*) shows the shape of the supporting frames. Six such two-span frames, set out on lines radiating from a common centre, carry

precast concrete slabs the spans of which vary from 10 ft. 1½ in. to 16 ft. 3½ in. The four central frames are supported at one end by steel tie-rods suspended from a tied two-pin parabolic arch. The outer two frames have an additional vertical support, and this is made use of to resist horizontal wind forces on the arch structure.

The design of the frames was assisted by constructing a perspex model to a scale of 1 in. to 4 ft. and applying known deformations in a Begg's deformometer. Influence lines for vertical and horizontal

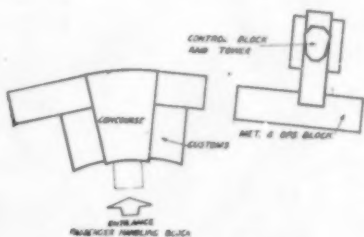


Fig. 1.—Site Plan.

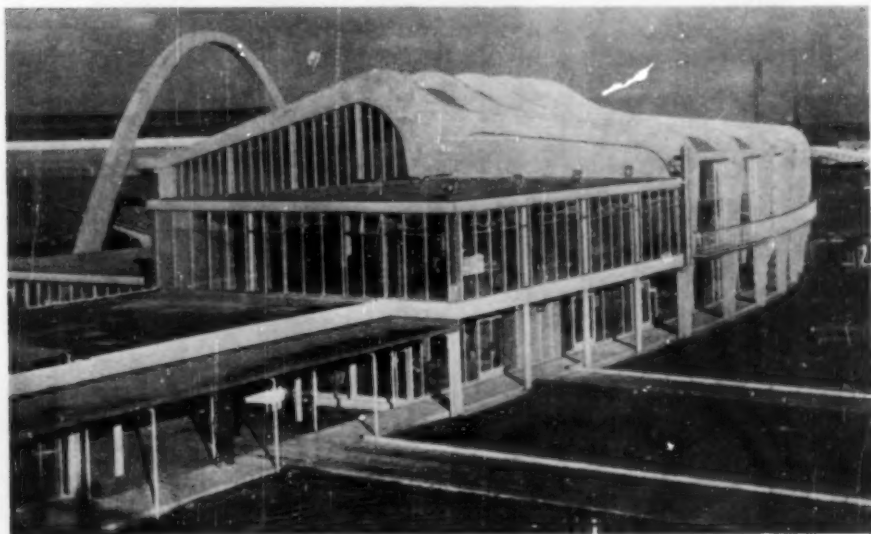
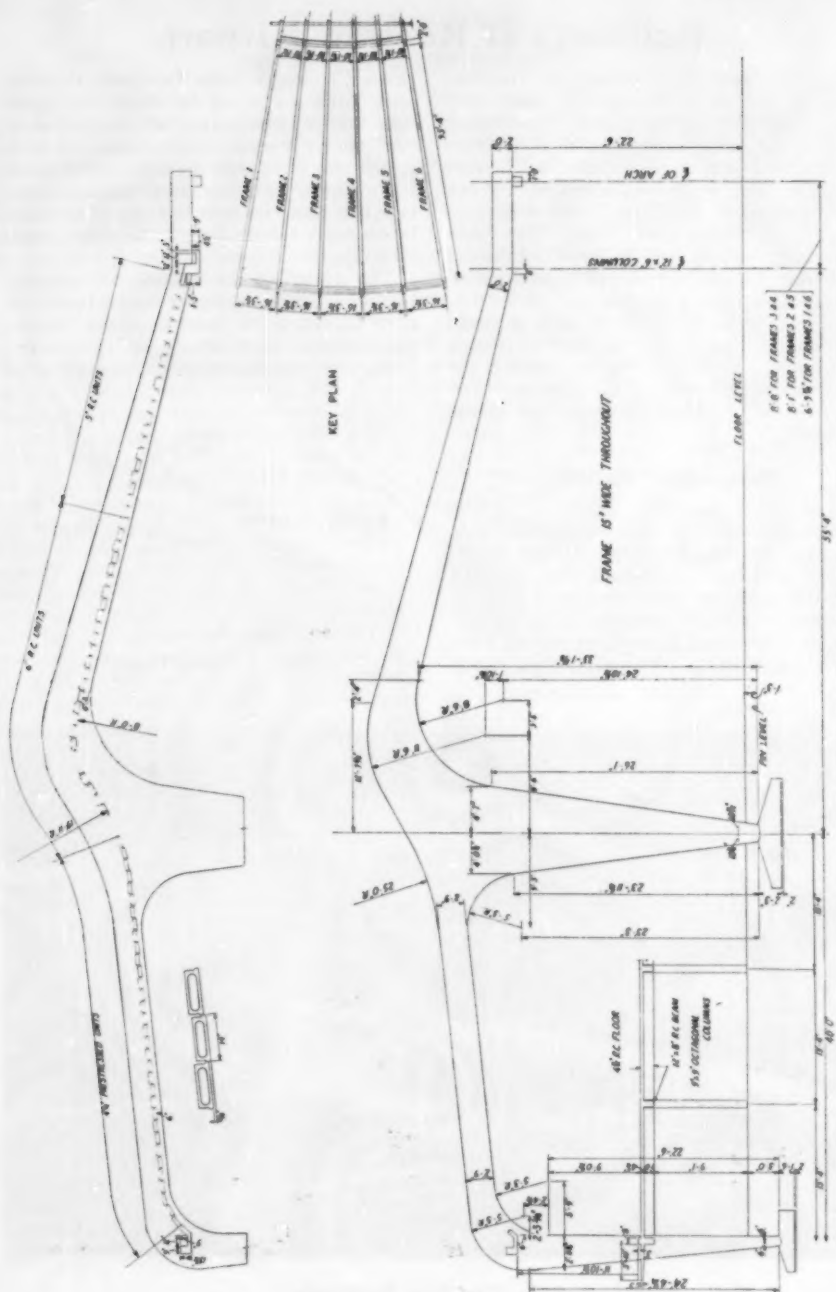


Fig. 2.—The New Buildings.



loads were then prepared and, from these, bending moments were calculated and the results plotted. The influence lines are shown in *Figs. 5 and 6* and the bending-moment diagrams for dead load, live load, and wind forces are shown in *Figs. 7 (a), (b), (c), and (d)*. When the shuttering was removed from the frames strain recordings were taken, and these confirmed the accuracy of the stresses calculated in the design.

The finished ceiling over the concourse is shown in *Fig. 10*. Alternate precast slabs are laid with their soffits  $\frac{1}{2}$  in. above their neighbours to give a serrated effect. Great care was required during erection of the slabs to ensure that the line of the

floor and roof slabs spanning in two directions between them.

At the main entrance to the concourse is a reinforced concrete canopy cantilevering 18 ft. over the space where passengers alight from road vehicles. A section through this canopy is shown in *Fig. 8*, and it is also seen in *Fig. 4*.

### **Control Tower.**

The control tower (*Fig. 11*), a longitudinal section through which is shown at *Fig. 9*, is a three-story building; the second-floor contains the control room and is 15 ft. above the level of the first-floor ceiling to provide an adequate view



**Fig. 4.—The Arch and Entrance to the Passengers' Building.**

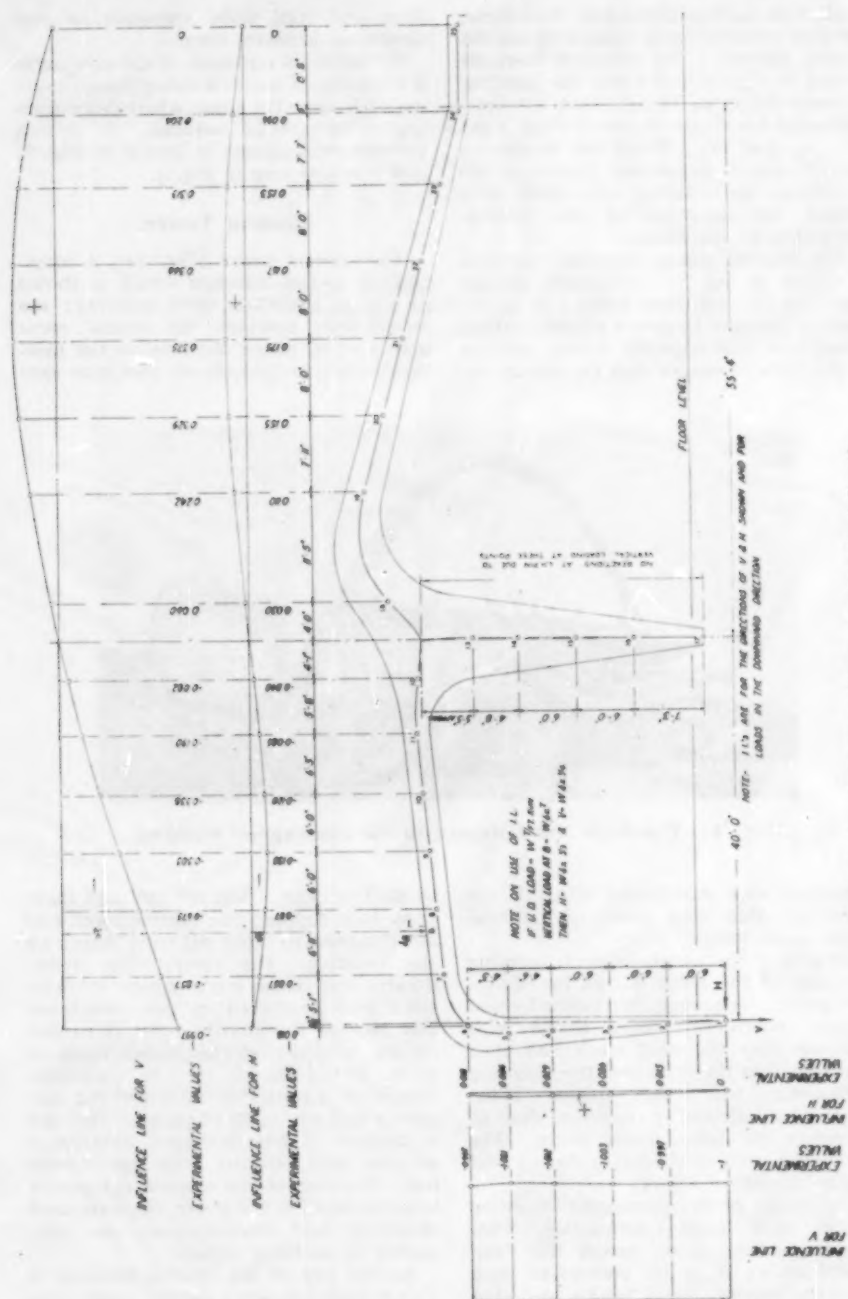
serrations was maintained through the bays and that they were symmetrical within each bay.

Details of the parabolic arch carrying the ends of the main frames are shown in *Fig. 12*. Temporary pin-joints formed during construction were closed with concrete after the dead loads had been transferred to the arch and the resulting settlements had taken place. These joints also allowed movement due to shrinkage to take place freely. The completed arch is shown in *Fig. 4* and also to the left of *Fig. 2*.

The wings of the passengers' building are of more usual construction. Octagonal columns, 9 in. across the flats, spaced at 13 ft. 4 in. centres in each direction support small beams and thin

in all directions. The lift-well and staircase shaft support the control room and are designed to resist all wind forces on the building. The surrounding floors, divided into panels 20 ft. square, are 9 in. thick and reinforced in two directions. The roof of the control room is carried on ten welded-steel box-frames made of 12-in. by 3 $\frac{1}{2}$ -in. by 26·37-lb. channels. This steel is protected by a sprayed zinc primer and two coats of paint. The roof is formed of trough-shaped aluminium sections and covered with bituminous felt. Because of the control equipment to be installed in the tower, the structural steelwork and reinforcement are connected to earthing tubes.

At one end of the control building is a very-high-frequency aerials' mast, seen



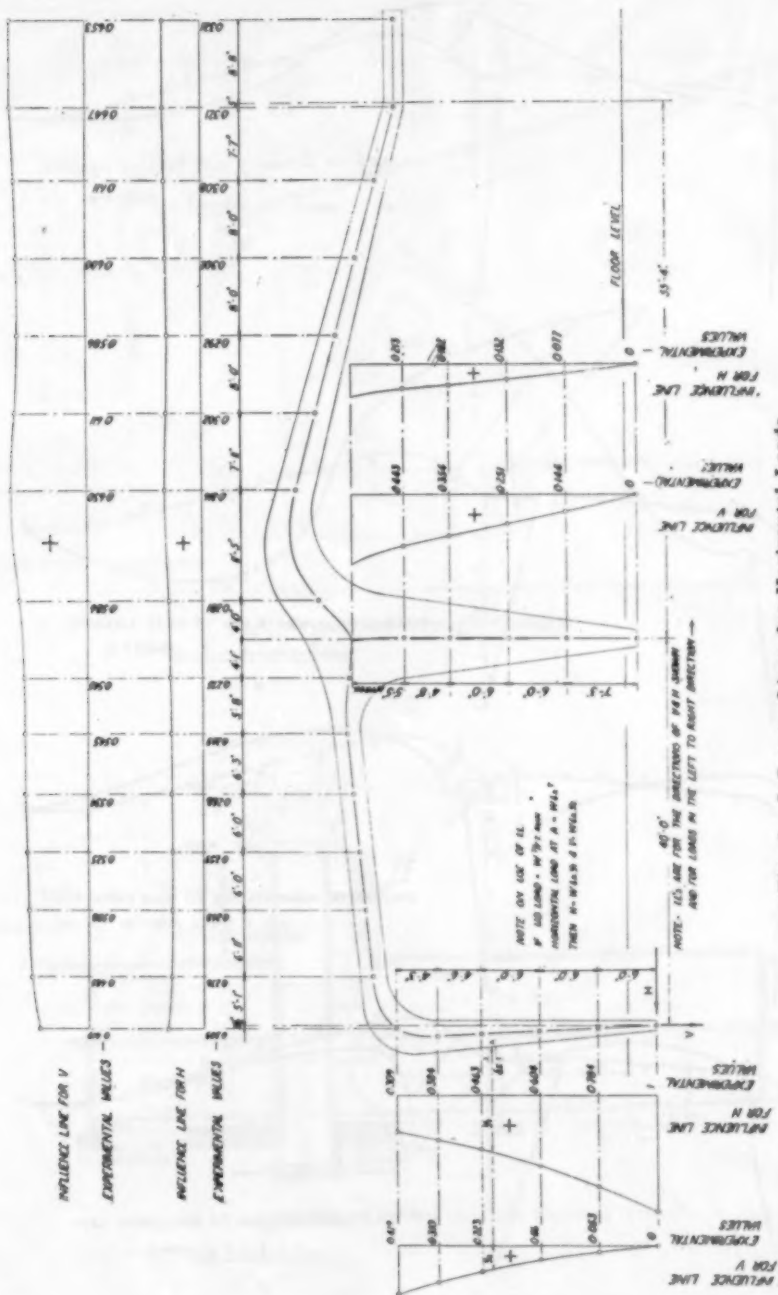


Fig. 6.—Influence Lines for Horizontal Loads.

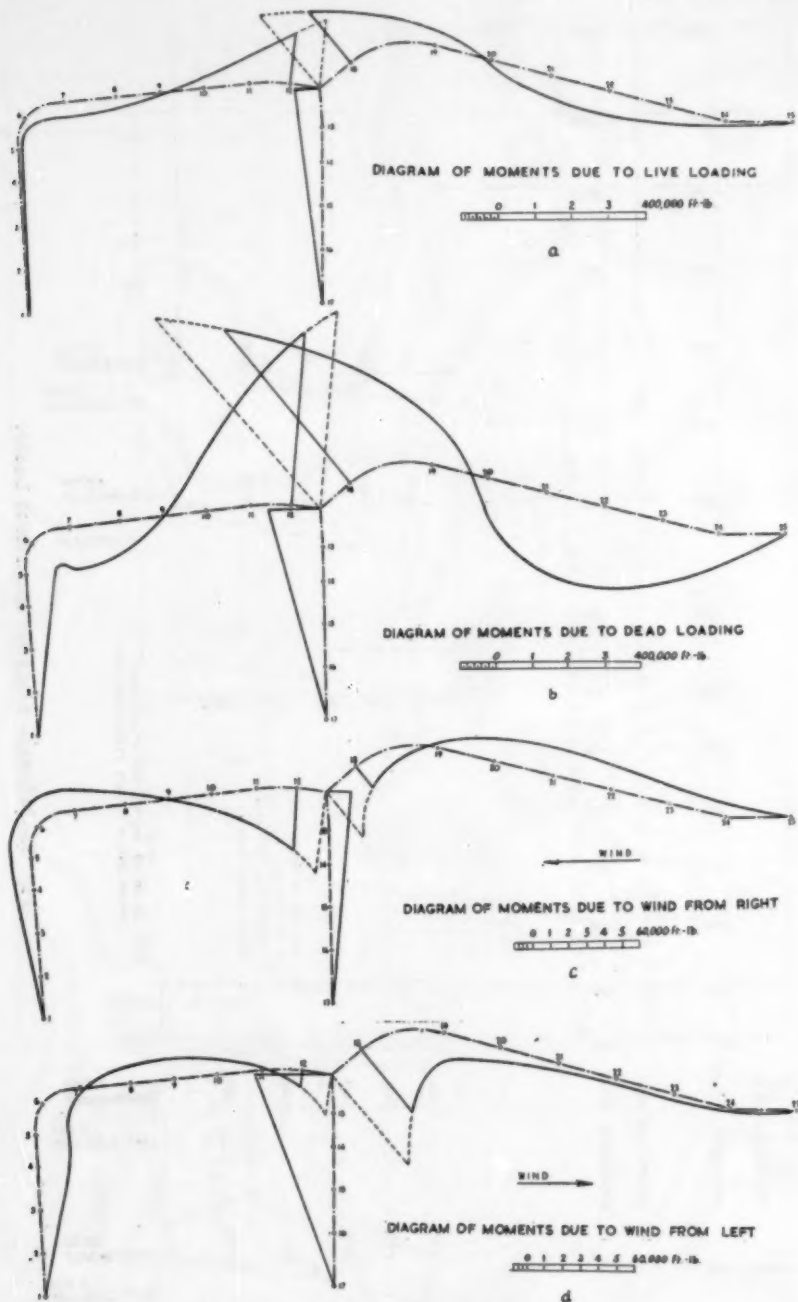
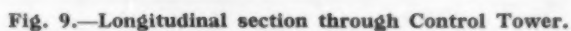
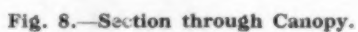
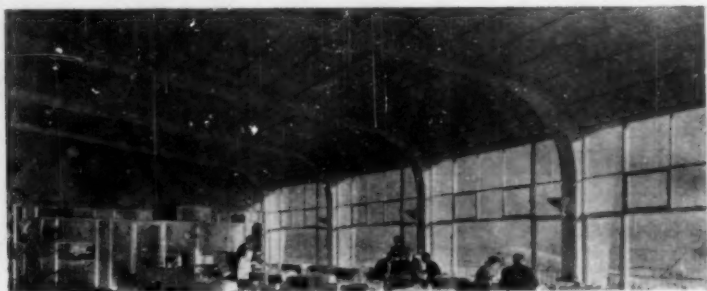
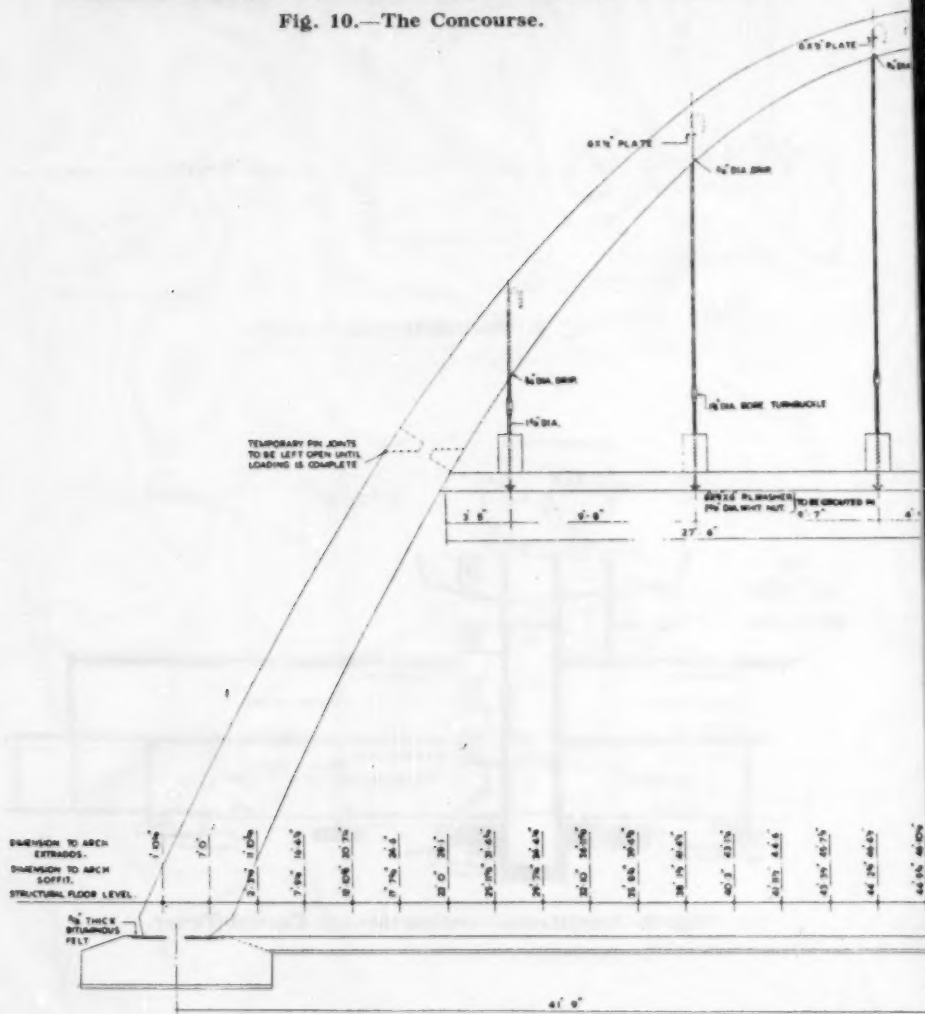


Fig. 7.—Bending Moment Diagrams.





**Fig. 10.—The Concourse.**



**Fig. 12.**

*December, 1954.*

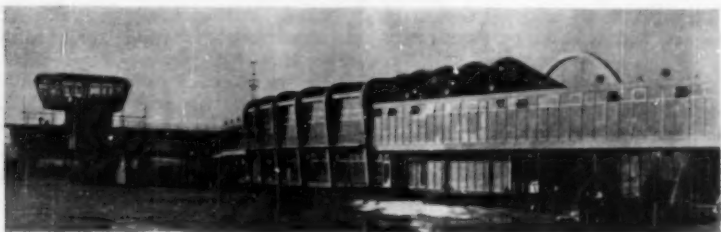
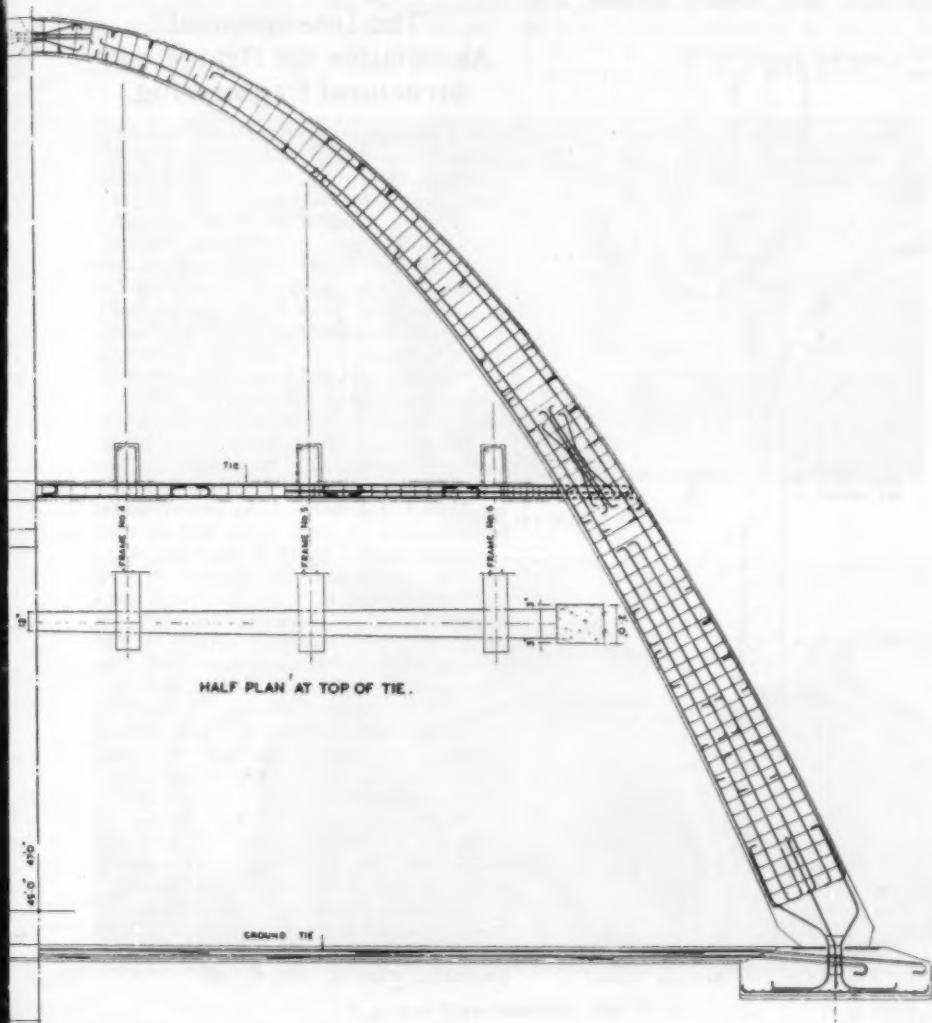


Fig. 11.—The Passengers' Building and Control Tower.



in Fig. 13; this is of unusual design in mild steel and is coated with a zinc spray.

### Materials.

Three qualities of concrete were specified with crushing strengths at 28 days of 3000 lb., 3750 lb., and 4500 lb. per square inch respectively; the actual strengths in all cases where tests were made exceeded the specified strengths. Ordinary Portland cement (or the Continental equivalent) was used throughout the work with washed pit-sand and

washed and graded gravel. All the reinforcement is mild steel complying with B.S. No. 785.

Messrs. Rowand Anderson, Kininmonth & Paul are the architects and Messrs. Blyth & Blyth the consulting structural engineers. The main contractors, who carried out all the reinforced concrete work, are Messrs. A. A. Stuart & Sons (Glasgow), Ltd.

## The International Association for Bridge and Structural Engineering.

THE fourteenth volume of the proceedings of the International Association for Bridge and Structural Engineering includes fourteen papers, as follows.

"The buckling of webs of flexurally-loaded plate girders, stiffened horizontally at the upper fifth-point of the depth," by Ch. Dubas. "The design of unsymmetrical prestressed girders with particular relation to creep and shrinkage," by B. Fritz. "Stability problems with axially-eccentric loading," by Elio Giangreco. "The effect of variable repeated loads in building structures designed by the plastic theory," by M. R. Horne. "Statistical calculation of the strength of reinforced concrete beams," by Arne I. Johnson. "An experimental investigation of slabs subjected to concentrated loads," by H. J. Kist and A. L. Bouma. "A numerical solution of the buckling problem," by Telemaco van Langendonck. "Buckling experiments on girders with stiffened webs," by Ch. Massonnet. "Measurement of the stresses in, and the deflection of, Kanzaki bridge," by Masao Naruoka. "Analysis of continuous conical shells by the method of successive approximations," by Gunhard Oravas. "Suspension bridges: the aerodynamic problem and its solution," by D. B. Steinman. "The theory of fatigue," by Fritz Stüssi. "Erection trusses for the replacement of existing plate girders," by Kazuo Tomonaga. "The exact theory of prismatic structures," by A. Werfel.

The volume is published by Verlag Leemann, Zurich, Switzerland.

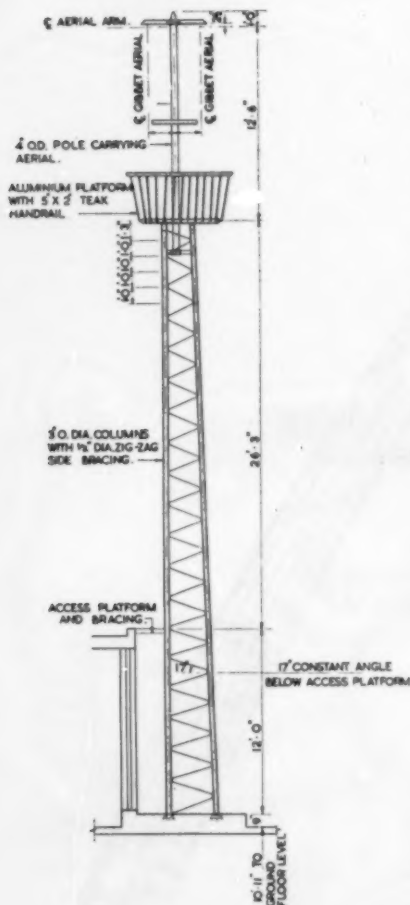


Fig. 13.—The Aerials Mast.

## A Cement Packing and Despatching Depot on the Thames.

THE new depot of the Cement Marketing Co., Ltd., at Carnwath Road, London, S.W.6, is unique in Great Britain in that the cement is delivered loose in lighters from cement works lower down the river and mechanically discharged in all weathers into silos, from which it is either packed in bags or delivered loose. Three 330-ton lighters can be unloaded simultaneously at the rate of 50 tons per hour each. The main elevations are shown in *Figs. 1 and 2*.

### The Wharf.

The existing river wall at the site was 17 ft. high of plain concrete, and trial holes revealed massive counterforts at about 12 ft. centres at the back of the wall. The wall had been built with its top level at about +12 ft. Newlyn datum and subsequently raised to about the +18-ft. level. To accommodate the lighters it was necessary to dredge to 3 ft. 6 in. below the bottom of the foundation of the wall and form a new

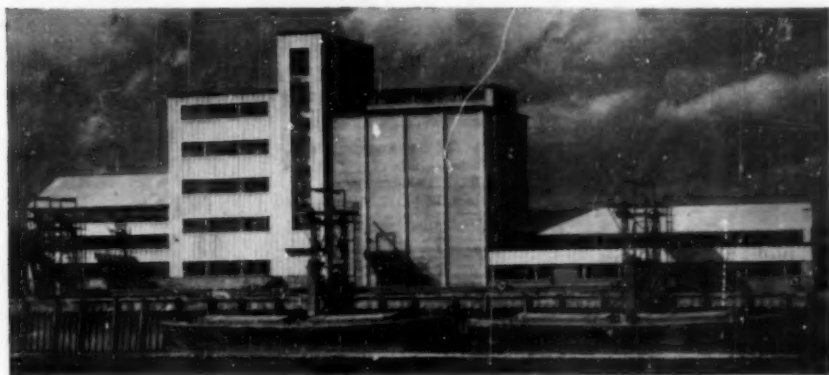


Fig. 1.—View from the River.



Fig. 2.—View towards the River.

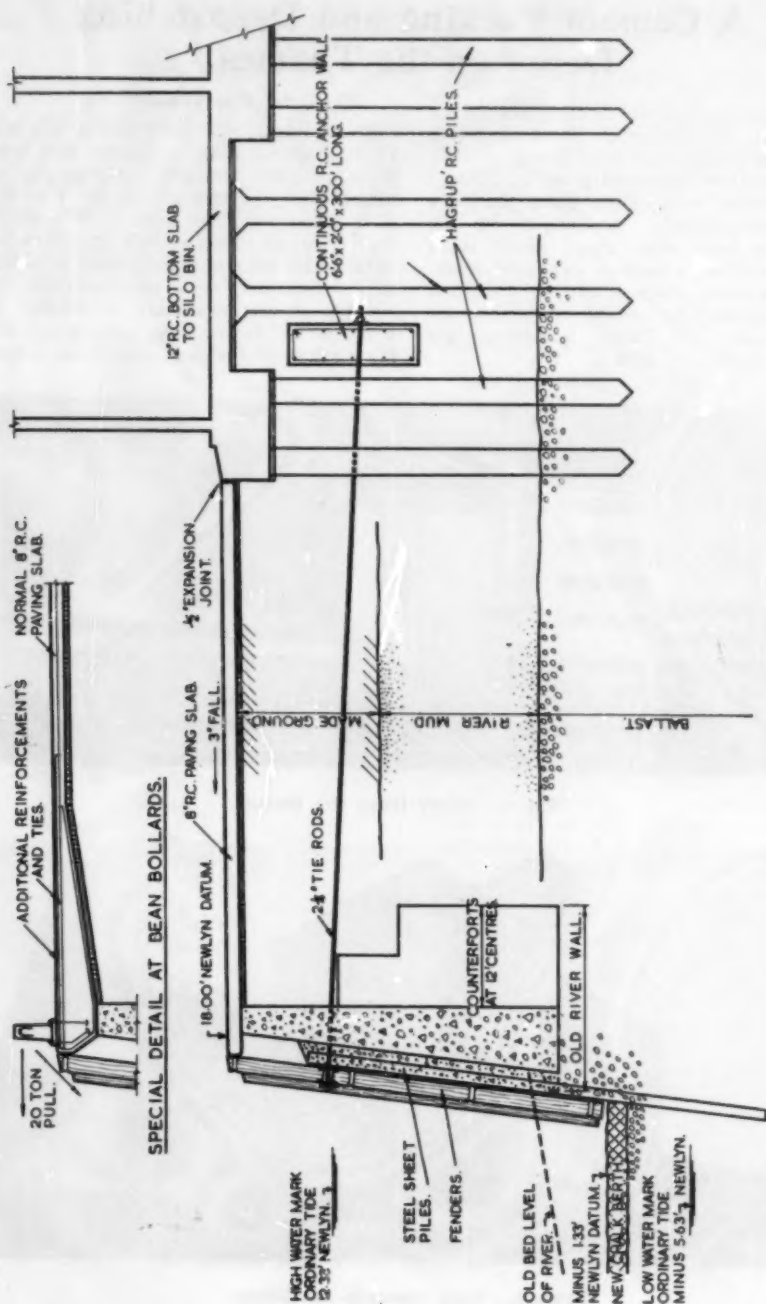
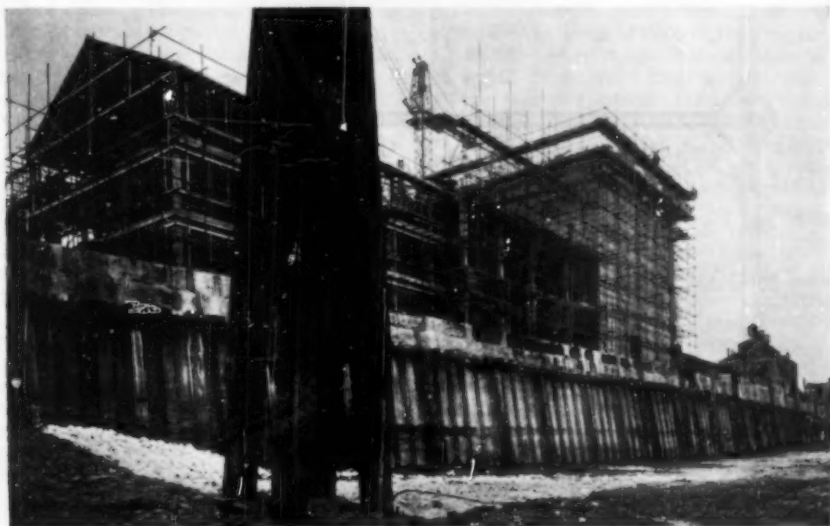


Fig. 3.—Transverse Section of Wharf.

chalk-bottomed berth at -1.33 ft. To maintain the equilibrium of the old wall, sheet piles were driven into the ballast of the river bed to 8 ft. below the level of the new berth, the tops of the piles being held back with steel-channel walings tied with rods 40 ft. long by 2½-in. diameter to a continuous reinforced concrete anchor wall, 6½ ft. by 2 ft. by 300 ft. long, 3 ft. 6 in. below the level of the wharf (Figs. 3 and 4). An experiment was made of driving reinforced concrete sheet piles in front of the wall, but driving into the ballast proved too severe and

concrete slab foundations, bearing on the river wall at the front and on piles at the rear. From the unloaders the cement is taken by screw-conveyors to bucket-elevators in the buildings and raised by two bucket-elevators to the top of the silos where distribution to the various bins is by means of air-slides. The elevator casings are 6 ft. 3 in. by 3 ft. 3 in. internally by 91 ft. 6 in. high; they are of reinforced concrete only 4 in. thick. The elevator casings are founded on the floor of a reinforced concrete pit 23 ft. below wharf level and about 18 ft.



**Fig. 4.—The River Wall and the Depot during Construction : New Dolphin in Foreground.**

the piles fractured in every case just below the bed of the river. Therefore second-hand steel sheet piles were used, with a plain concrete filling between the piles and the old wall. The paving of the front of the wharf is 8 in. thick, laid on 8 ft. of made ground overlying 8 ft. of river mud. This paving is strongly reinforced due to the nature of the filling, and in order to tie back and spread the horizontal forces of 20 tons on the Bean bollards and capstan winches.

#### **The Elevators.**

The bucket-elevator unloaders on the front of the wharf rest on reinforced

below high-water mark at ordinary tides.

In excavating for this pit a natural spring was struck necessitating the laying of temporary drainage to a deep sump from which the water was pumped through a 4-in. discharge pipe to the river. As a result of encountering this spring, the lower 10 ft. of the pit was tanked externally with asphalt as an added precaution, and the pit remains completely dry.

#### **Silos and Packing Plant.**

The total storage capacity of the silos is 6000 tons, comprising twelve bins 13 ft. 4 in. by 16 ft. 3 in. by 63 ft. high

arranged in three rows of four (*Fig. 5*). The inner walls of the bins are generally 6 in. or 7 in. thick, depending on the length of the spans, with  $\frac{3}{4}$ -in. cover to the reinforcement; the external walls of the external bins are 7 in. or 8 in. thick to provide an additional 1 in. of cover, making a total cover of  $1\frac{1}{2}$  in.

The silos were constructed with climbing shuttering in 3-ft. lifts. All the walls of all the bins were concreted the full height of each lift so that there are no vertical construction joints. The horizontal joints in the external walls are

rebated and also provided with galvanised-steel water-bars 4 in. wide set 2 in. in the concrete on completion of a lift, and projecting 2 in. into the concrete of the following lift, in order to provide the complete weathertightness necessary in structures for storage of cement.

The external shutters were lined with hardboard to give the concrete a smooth and even texture, and the shutters were struck as soon as the concrete was sufficiently hard and immediately rubbed with a hardwood float. The concrete was consolidated by immersion-type vibrators

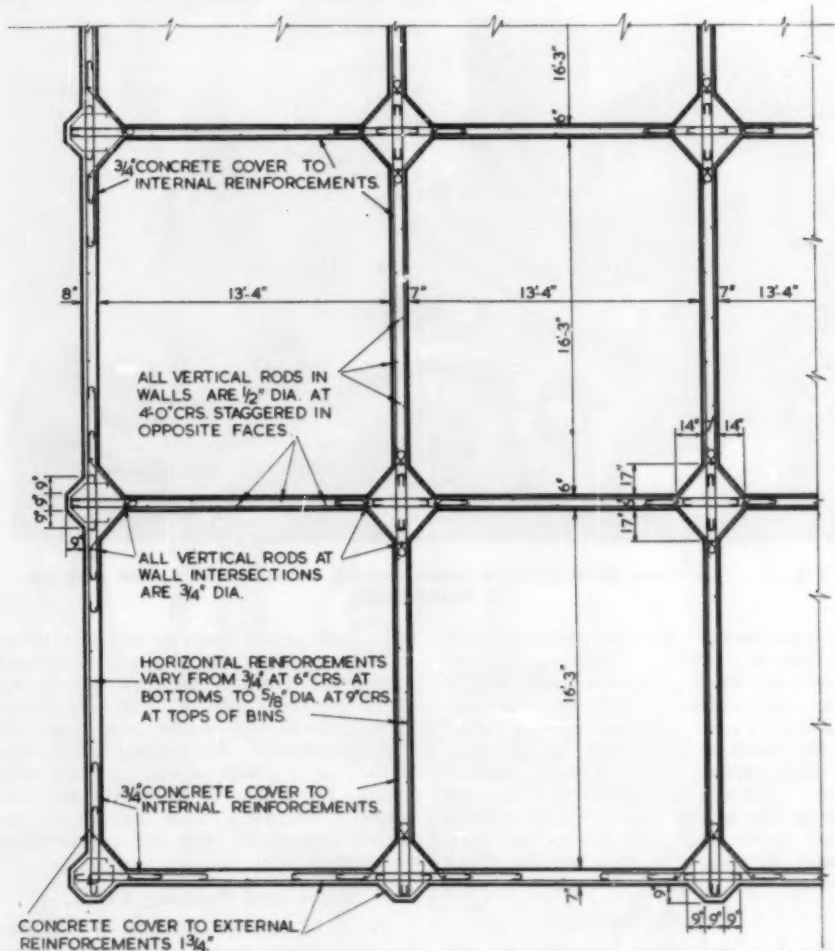


Fig. 5.—Part Plan of Silos.

which caused the concrete to fill the shutter completely, so that no touching-up of the face was required or allowed. The consulting engineers specified precisely the quality of the finish required, and the contractors gave this matter close attention with successful results.

From the silos the cement is taken by air-slides to two elevators in the packing department. These elevator casings are of reinforced concrete 4 in. thick similar to the casings of the elevators to the silos. At present one 12-spout bag-packing machine is in use, but provision is made for a second similar machine to be installed later. The packing machine is supplied from a hopper of 20 tons capacity situated immediately above. The packing department is a five-story reinforced concrete framed building clad with asbestos-cement sheets, except for the lower 7 ft. where concrete blocks are used. All external block walls are of cavity construction with two 3-in. leaves and a 3-in. cavity.

The bagged cement is conveyed on a 24-in. belt from the packer to the loading department where it is taken by retractable belt-conveyors on to lorries.

The loading department is three-stories high; it is a reinforced concrete frame generally, but the pitched roof has steel trusses clad with asbestos-cement sheets on the grounds of economy and speed of erection. The steel trusses are secured to the tops of the reinforced concrete columns by rag-bolts. The walls are of asbestos-cement sheets and concrete blocks. The top floor of the loading department comprises a bag store with a useful capacity of 750,000 bags.

## Foundations.

Three borings taken on the site about 50 ft. from the river wall indicated about 8 ft. of made ground overlying about 8 ft. of river mud and then about 20 ft. of sand and ballast over London clay. It was therefore decided to use piled foundations for the silos, the packing department, and loading department; spread foundations were used for the other buildings. The piles were the "Hagrup" type, of Swedish origin, hitherto used in this country experimentally only. These piles are formed by driving a steel tube of 1 ft. 6 in. diameter with a reinforced concrete shoe until the required set is reached, and then

placing reinforcement in the tube and filling it with concrete. The tube is then extracted. The main feature of this pile is the control exercised in placing the concrete. Within the main tube is a tremie-pipe of 8 in. diameter enlarged at its lower end. A measured quantity ( $2\frac{1}{2}$  cu. ft.) of concrete is poured into the tremie-pipe and the tube then extracted a measured distance. By observing the fall in level of the concrete in the tremie-pipe in relation to the measured distance of extraction of the tube it is possible to know the diameter of the pile formed in the ground and so ensure that the pile is the required diameter throughout. On this site the piles obtained the required set in the ballast more suddenly than was expected. The piles were driven with a 3-tons hammer falling 4 ft. to a set of 48 blows to the foot. They are designed for a safe working load of 50 tons each. Two of the completed piles were tested with a load of 100 tons and settled less than  $\frac{1}{4}$  in.

## Other Structures.

On the loading side of the main buildings, a structural steel canopy cantilevering 30 ft. is provided to give cover to lorries and the loading operations. A platform from which the pipes for loading loose cement are controlled is suspended from the cantilevered trusses.

Other buildings at the depot comprise stores, workshops, repair garage, cover for thirty lorries, substation, office block, and canteen. The office and canteen is a reinforced concrete frame with wall panels of concrete blocks made with lightweight aggregate. These lightweight blocks enabled economies to be made in the design of the structure, and also give good thermal insulation. The roof of the office is covered with 2 in. of expanded clay with the finer particles removed to insulate the slab from the effects of solar radiation. Although the building is 115-ft long without expansion joints, there are no signs of thermal movement. The walls of the office and substation are treated externally with a textural waterproof finish.

The new boundary fence, 7 ft. high, is in precast concrete in a weatherboard pattern. No rainwater pipes or plumbing are exposed on the elevations. All soil drainage and some of the storm-water are led to the existing sewer. Most of the

storm-water, however, is taken through non-return traps to discharge through the river wall into the Thames.

The consulting engineers to the Associated Portland Cement Manufacturers, Ltd., for the whole of the civil engineering

and building work were Messrs. Oscar Faber & Partners. The main contractors were Messrs. John Mowlem & Co., Ltd., and the steelwork contractors were Messrs. Redpath Brown & Co., Ltd.

## Strip Steel for Prestressed Concrete.

IN the Journal of the American Concrete Institute for January, 1954, Mr. K. P. Milbrat gave details of tests made at the Illinois Institute of Technology on a prestressed concrete beam 21 ft. long, a cross section of which is shown in Fig. 1. The steel used was plain tempered spring-steel strip, 0.048 in. thick by 0.625 in. wide, which had a 0.1 per cent. proof stress of 182,000 lb. per square inch and a breaking strength of 215,000 lb. per square inch. The ratio of perimeter to cross-sectional area of the strip is 45, which is equivalent to the ratio of a circular wire of 0.089 in. diameter; the cross-sectional area of the strip is 4.75 times as great as that of the wire. Clamps (Fig. 2) were used to anchor the strips until the concrete had hardened. Similar clamps have been used to secure 18 strips, and the force applied to them has been as great as 67,000 lb.

To test the efficiency of these clamps, steel strips anchored in them were subjected to a pull which produced a stress in the steel of up to 216,000 lb. per square inch; at this stress half of the strips broke outside the clamps. The steel in the test beam was tensioned to produce a stress of 155,000 lb. per square inch; losses due to the buttresses when the force was transferred to the concrete left a working stress of 120,000 lb. per square inch. The steel strip would break at an elongation of 5 per cent. but only 20 per cent. of this elongation had been developed when the test beam failed with a deflection of 9 in. The writer suggests that in steel for prestressed concrete an elongation of 2 per cent. is sufficient to permit large deflections in simple beams. He also concludes that the steel strip remained bonded to the concrete from the time the prestressing force was transferred to the concrete until the beam was broken. For his experiments the writer used commer-

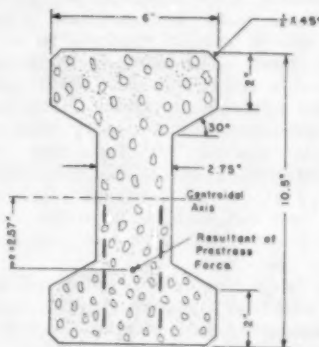


Fig. 1.

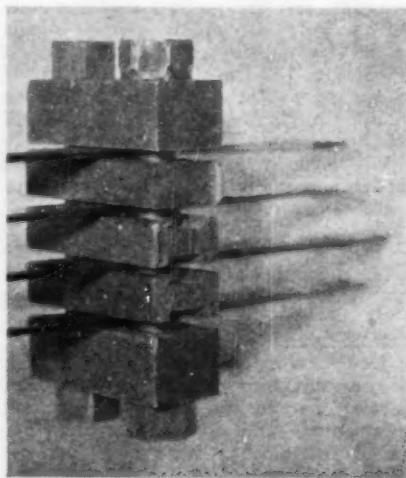


Fig. 2.

cially-available steel with a blued surface. No details are given of the method of tensioning the steel, or of the clamps.

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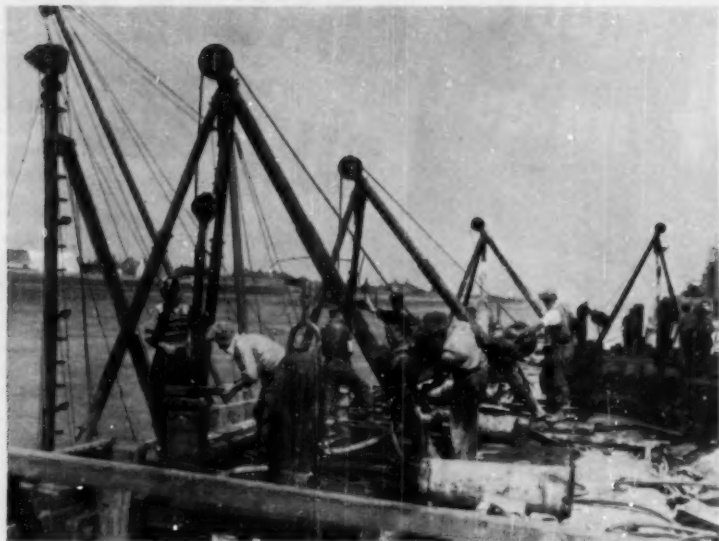
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*The work was carried out for the King's Lynn Conservancy Board and their Consulting Engineers, Messrs. Wilton & Bell, M.M.I.C.E., London. The General Contractors were the Dredging & Construction Co., Ltd., King's Lynn, and John Gill Contractors, Ltd., London, were the sub-contractors for Prestcore piling.*

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## A Precast Concrete Hangar.

A HANGAR of 130 ft. span and 160 ft. long, recently built in Canada, is designed so that it can be dismantled and re-erected elsewhere if necessary. The side bays are about 18 ft. wide (*Fig. 1*) and accommodate offices and workshops. The main roof members are three-hinged arch ribs with a rise of 18 ft. and a span of 110 ft.; these are supported on columns with cantilevers that project 10 ft. into the bays.

The sloping roof beams and the outer columns of the side bays are formed by single members, the lower ends of which are hinged to the foundation; the upper ends are hinged to and supported by the columns that form part of the main bay. The frame formed by the members of the side bays and main bay is statically determinate and is therefore not affected by changes of temperature, shrinkage of the concrete, or settlement of the foundations.

The arrangement of the frame is such that most of the dead load and evenly-distributed live load is transferred to the outer columns of the side bays, which also transmit the horizontal thrusts to the foundations. The vertical load on the columns between the central span and bays is small, and under certain conditions of loading a slight uplift force occurs; this is counteracted by the weight of the foundation to which these columns are fixed. The foundations of the outer columns of the side bays are continuous reinforced concrete strips and are connected to the foundations under the columns between the bays by reinforced concrete ties so that the resistance to sliding may be increased.

The frames are at 10-ft. centres so that the heaviest precast member weighs less than 12 tons. The reinforced precast concrete roof slabs are, generally, 18 in. wide. As there are no purlins, reinforced concrete stiffeners between the frames transfer the lateral forces to adjustable steel wind bracings between the three central frames.

The specified crushing strengths of the concrete (tested as cylinders) were 4250 lb. per square inch for the superstructure and 3000 lb. per square inch for the roof slabs. The hangar was designed for a snow load of 40 lb. per square foot and a wind pressure of 30 lb. per square foot.

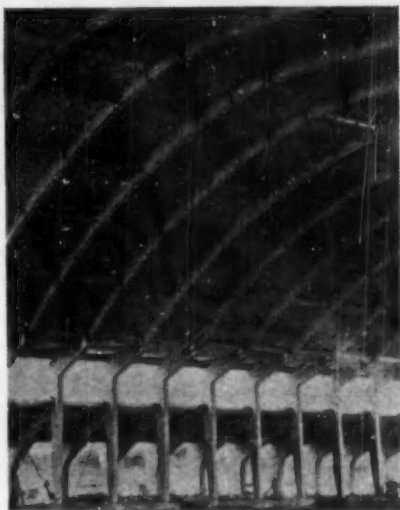


Fig. 1.—Part of the Main Bay and a Side Bay.

The arch ribs are 10 in. wide and vary in depth from 1 ft. 3 in. to 2 ft. 2 in. and each half of the rib weighs about  $6\frac{1}{2}$  tons. The columns between the bays are 1 ft. wide and weigh about  $7\frac{1}{2}$  tons each. The members forming the side bays are 1 ft. 3 in. wide, have a maximum depth of 4 ft. 10 in., and weigh 11 tons each.

The hinges of the arches and those at the tops of the outside members are made of cast steel. All the hinges are alike and allow for movements in the plane of the frame and also perpendicularly to this plane; the hinges have spherical contact surfaces, the convex surface being curved to 8-in. radius and the concave surface to  $9\frac{1}{4}$ -in. radius. The shearing forces, which are small, are transmitted through small tapered steel pins at the centre of the hinges which allow for angular movements. The hinges were cast into the concrete and anchored by four  $\frac{1}{2}$ -in. diameter steel bars welded to the base of the hinge and surrounded by helical steel binders. *Fig. 2* shows the convex part of a hinge and *Fig. 3* shows the end of one of the arch ribs with the concave part of a hinge in place.

The hinges between the outer columns

of the side bays and the foundations were formed in concrete. A small precast block (Fig. 4) with a curved surface of slightly larger radius than the end of the column was placed in the foundation and a sheet of medium-soft lead interposed between the two curved surfaces. The shearing force at this hinge is resisted by a 2-in. diameter steel pin which projects from the bearing block, is slightly tapered, and engages in a steel ferrule fixed in the end of the column. As the forces on the columns between the bays were small, hinges were not provided at the bases; instead, the connections were formed by steel bolts engaging in stirrups, made of steel strip, projecting from the foundation.

The members forming the side bays and the columns between the bays were de-

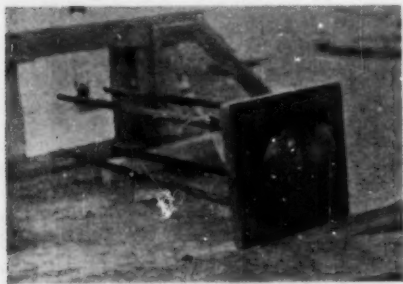


Fig. 2.—The Convex part of a Hinge.

signed so that they could be cast horizontally and tilted into position. The halves of the arch ribs were cast, with the extrados uppermost, on a curved casting bed in order to avoid undue handling stresses. Erection was generally started fourteen days after casting. The members for the side bay were erected first by supporting them on adjustable struts. The columns between the bays were then erected and connected to the side bays with the temporary steel straps. The stiffeners connecting adjacent frames and the diagonal bracing in the side bays were then erected.

An arch exerts at its springings vertical and horizontal forces due to dead and live loads. It was therefore thought desirable to cause similar forces at the ends of the arch ribs during erection, as they were not strong enough as simply-supported beams carrying their own weight. Accordingly, the following method was adopted.

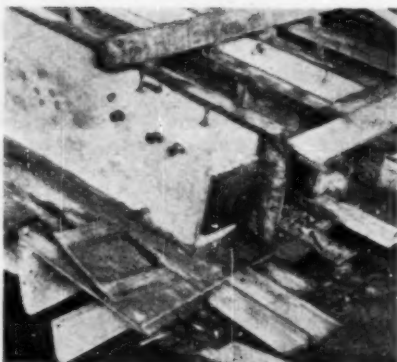


Fig. 3.—The End of an Arch Rib.

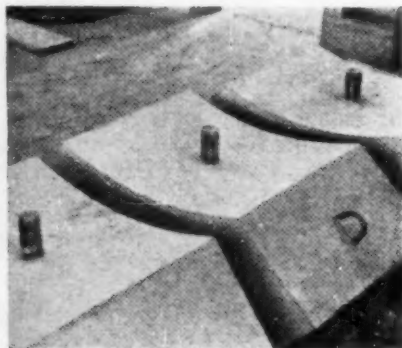


Fig. 4.—Precast Blocks for Hinges of Columns between Bays.

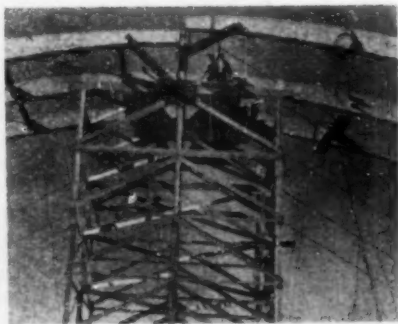


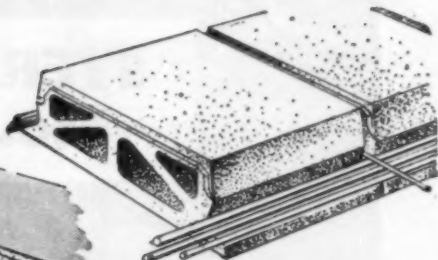
Fig. 5.—Arch Ribs being Erected.



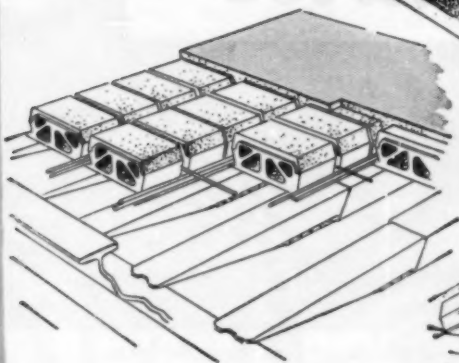
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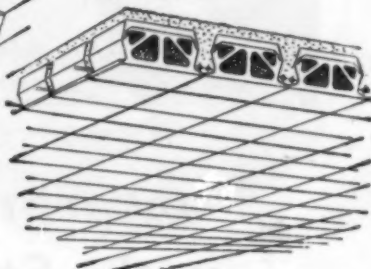
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## A Large Prestressed Tank.

A WATER tank of 12,000,000 gallons capacity (Fig. 1) has been constructed at Richmond, California, U.S.A. The tank is 200 ft. diameter and 43 ft. 8 in. high and has a domed roof and concave floor. The wall is prestressed vertically and horizontally by high-tensile wires of 0.196 in. diameter which were tensioned by Freyssinet jacks. The horizontal wires are in cables of 18 wires each in flexible metal tubes of  $1\frac{1}{4}$  in. diameter. The spacing of the cables increases from  $3\frac{1}{2}$  in. near the bottom of the wall to 2 ft. at the top; in the ring-beam on top of the wall there are additional cables to withstand the thrust from the roof (Fig. 2). Each circumferential cable is

stress in the concrete will be nearly uniform.

The wall is unrestrained at the bottom but the friction between the wall and the base causes a vertical bending moment in the wall; to counteract the tension in the concrete due to this bending moment the wall is also prestressed vertically. The vertical cables are similar to those used in the horizontal direction but are in smooth light-gauge tubes at 2 ft. centres. The lower ends of the wires were embedded in the concrete and they were tensioned after the horizontal wires.

The design is such that the compression in the concrete will not exceed 1000 lb. per square inch, and when the tank is full

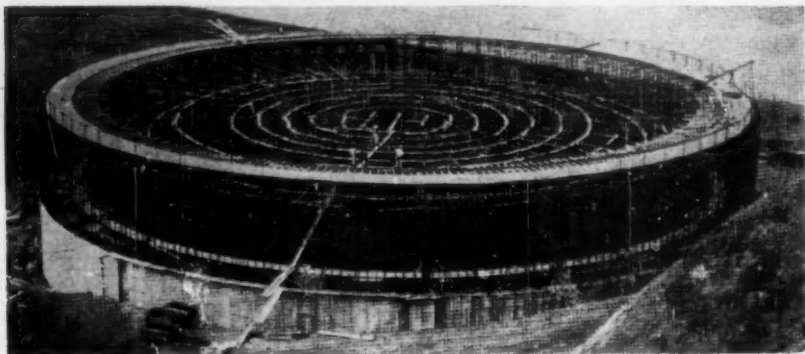
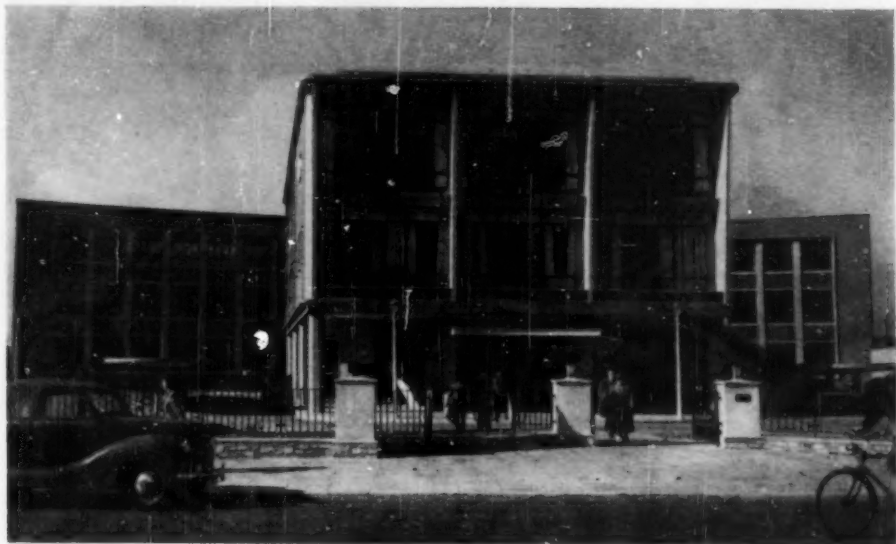


Fig. 1.—Tank during Construction.

in four parts; on the outside of the wall there are eight pilasters and alternate cables are anchored in alternate pilasters. The wires were tensioned from each end, and the hydraulic power for operating the jacks was supplied by a compressed-air pump from which four jacks were operated simultaneously. The wires were tensioned to 188,000 lb. per square inch, and it is anticipated that due to creep and other losses the stress remaining in the wires will be about 166,000 lb. per square inch at the ends; further losses due to friction between the wires and the tubes are estimated to reduce the initial stress at the middle of the cables to about 146,000 lb. per square inch. As the middle of each cable corresponds to the ends of those above and below it, the compressive

the wall will still be in compression. The concrete is 2 ft. thick at the bottom reducing uniformly to 1 ft. at a height of 24 ft. The roof has a minimum thickness of  $4\frac{1}{2}$  in. The ring-beam was partially prestressed before the roof was constructed and completely prestressed when the concrete in the roof had hardened so that the dome was put into a state of compression.

The junction between the wall and the base is sealed by a rubber tube with a half-round steel bar above and below it. The bottom bar is drilled and threaded to receive a stud that passes through the tube and the upper bar. When the nuts at the top of the studs are tightened, the tube is compressed against the wall and floor of the tank.



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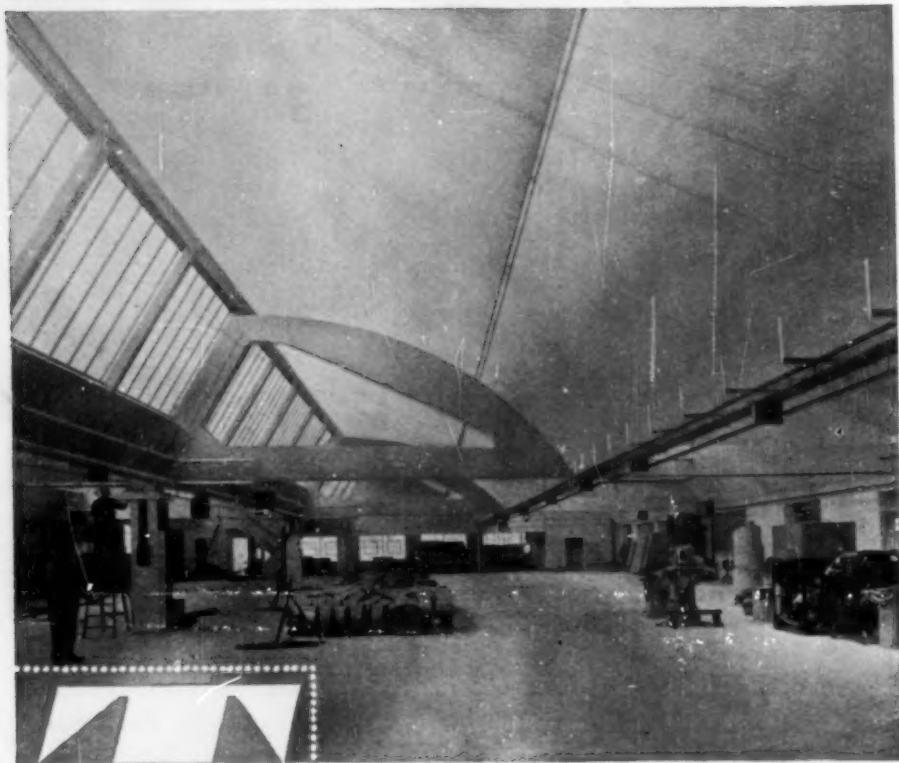
## **SIMPLEX CONCRETE PILES LTD.**

25 BRECHIN PLACE,

SOUTH KENSINGTON,

LONDON, S.W.7

Telephone: Fremantle 0035-6



Factory : Underwood, Elliott & Fisher.  
Architect : R. Seifert, F.R.I.B.A.  
Contractors : Rice & Son Ltd.

# **TWISTEEL**

## *and the Barrel Vault*

**This is a factory.** Light and clean, airy and un-oppressive : it could equally well be a studio, with the curve of the barrel vault roof reflecting the ample north light evenly over broad floor areas. Note the lack of obstruction to the floor space by structural supports : and the absence of dust traps in the clean sweep of the Wireweld-reinforced Twisteeel-designed roof.

### **TWISTEEL REINFORCEMENT LIMITED**

LONDON : 43 UPPER GROSVENOR STREET, W.1. Tel: GROsvenor 8101 & 1216 . MANCHESTER : 7 OXFORD ROAD, MANCHESTER, 1. Tel: Ardwick 1691 . BIRMINGHAM : ALMA STREET, SMETHWICK, 40. Tel: Smethwick 1991.  
GLASGOW : 19 ST. VINCENT PLACE, GLASGOW, C.1. Tel: City 6894

The concrete in the lower 8 ft. of the walls comprises 660 lb. of cement and 35 lb. of pozzolana to 1 cu. yd. of aggregate of  $\frac{3}{4}$  in. maximum size. The concrete in the rest of the wall comprises 625 lb. of cement and 33 lb. of pozzolana per cubic yard and the maximum size of aggregate is  $1\frac{1}{2}$  in. An air-entraining agent was used in all the concrete, and the water-cement ratio varied between 0.4 and 0.47. A compressive strength of 4500 lb. per square inch was required in all the concrete.

As a result of experience in the construction of thirty prestressed tanks, the owners have decided not to have horizontal construction joints in future tanks. In the tank described the vertical construction joints were at first 80 ft. apart; due to the appearance of shrinkage cracks the vertical joints in the remainder of the tank are 40 ft. apart.

Mr. R. C. Kennedy is the chief engineer of the East Bay Municipal Utility District (for whom the tank was built), and the work was designed under the supervision of Mr. J. W. Trahern. The

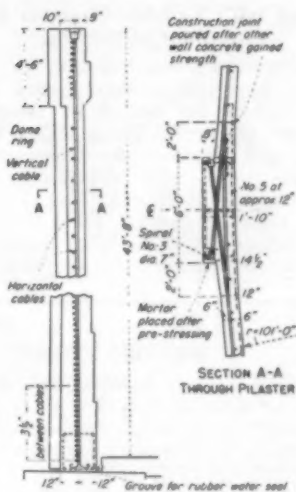


Fig. 2.—Details of Wall.

foregoing notes are abstracted from "Engineering News Record" for May 20, 1954.

### Expanded-clay Aggregate and Insulation.

The Cement Marketing Co., Ltd., announces that Leca expanded-clay will not be made after December 31, 1954, but supplies will be available for all outstanding contracts. The Company states that production of this material has been stopped reluctantly as its advantages as a thermal insulating material and light-weight aggregate had been proved conclusively. The increases in the cost of fuel and transport since Leca was first marketed have, however, so increased costs that it cannot now be offered at an economical price.

### AGENTS WANTED.

AGENTS WANTED WORLD-WIDE. Revolutionary formwork system for concrete construction. 9-ply formwork boards. Tubular steel props. Write at once for full description to Export Manager, A/S STORMBULL, Storgt. 102, Oslo, Norway.

### CITY OF BIRMINGHAM EDUCATION COMMITTEE. COLLEGE OF TECHNOLOGY, BIRMINGHAM. DEPARTMENT OF BUILDING & CIVIL ENGINEERING. SPECIAL ADVANCED LECTURES. SHELL CONCRETE CONSTRUCTION.

A series of six lectures by:—  
C. Brewington, B.Sc. (Hons.), A.M.I.C.E.,  
A.I.M.U.N.E., Lecturer in Civil Engineering.  
TUESDAYS: 6.30–8.0 p.m.

Commencing—11th January, 1955

Fee £1 10s. od.

Full particulars and Application Forms from the Registrar, College of Technology, Birmingham.

E. L. RUSSEL,  
Chief Education Officer.

### FOR SALE.

FOR SALE. Steel guttering, general ironwork, moulds, etc. E. STEPHENS & SONS, LTD., Bath Street, London, E.C.1.

FOR SALE. 3/8-in. dia. mild steel rods, 60 tons, 10 ft. 6 in. long. Offered for reinforcing with Sommerfeld netting. Immediate delivery. PIKE BROS. (IRON & STEEL), LTD., Colnbrook, Bucks. Telephone 175

### FOR HIRE.

FOR HIRE. Lattice steel erection masts (light and heavy), 30 ft. to 150 ft. high, for immediate hire. BELLMAN'S, Terminal House, London, S.W.1. Telephone: Sloane 5259.

### Beams with Sudden Changes in the Moment of Inertia.

COEFFICIENTS for calculating the stiffnesses, fixed-end moments, and carry-over factors for beams in which the moment of inertia varies suddenly are given in "Constants for design of continuous girders with abrupt changes in the moment of inertia" by Professor R. A. Caughey and Mr. R. S. Cebula, in Bulletin no. 176 of the Iowa Engineering Experiment Station. Although it is prim-

arily applicable to steel beams with plates riveted or welded to the flanges, the information given could also be applied to reinforced concrete beams in which the moment of inertia varies in the same manner. The constants are shown by means of graphs and their derivation is by the moment-area method. Copies of the bulletin may be obtained free upon request to the Director, Iowa Engineering Experiment Station, Ames, Iowa, U.S.A.

#### TENDERS REQUIRED

### WEXFORD COUNTY COUNCIL—REPUBLIC OF IRELAND

#### CONSTRUCTION OF REINFORCED CONCRETE BRIDGE

The Wexford County Council invites tenders from Civil Engineering Contractors, experienced in construction of reinforced concrete bridges and in underwater works, for the building of a new reinforced concrete bridge over the River Slaney at Wexford.

The Bridge is approximately 35 ft. wide and 1,883 ft. long, divided into:—

- (a) Five arch spans of 779 ft. 8 in. overall, including one 150 ft. arch span, two 144 ft. arch spans and two 128 ft. 6 in. arch spans and two main abutments.
- (b) Eight approach spans of articulated portal frame construction of 74 ft. span each.
- (c) Embankments incorporating the existing old bridge approaches, sheet piled and filled to appropriate levels, about 149 ft. long at the South Western end and about 362 ft. long at the North Eastern end.

The foundations are reinforced concrete piles. The intermediate arch piers and main abutments will be constructed inside cofferdams to below river bed level which averages about 24 ft. below high tide.

Drawings, Specifications, Conditions of Contract and Bills of Quantities have been prepared by the Council's Consulting Engineer, Mr. W. J. L. O'Connell, M.E., F.R.I.C.S., M.Inst.C.E.I., 9 South Mall, Cork.

The Council does not bind itself to accept the lowest or any tender. The time taken for completion will be taken into account in deciding on the award of the contract. The acceptance of the tender will be subject to the approval of the Minister for Local Government.

Applications for copies of documents, Plans, Specifications, Conditions of Contract, Bills of Quantities and Drawings, should be made to the Consulting Engineer,

Mr. W. J. L. O'Connell, M.E., F.R.I.C.S., M.Inst.C.E.I., 9 South Mall, Cork, accompanied by a deposit of £50 (returnable after receipt of a bona-fide tender not subsequently withdrawn).

The documents may be inspected either at the County Council Offices, County Hall, Wexford, or at the offices of the Consulting Engineer.

Tenders on the prescribed form (unaltered in purport), signed and in a sealed envelope endorsed with the name of the contractor and the words "Tender for Wexford Bridge," must be delivered to the undersigned not later than 12 o'clock noon on Monday, 14th February, 1955. Separately sealed Bills of Quantities fully priced and extended and totalled in ink and endorsed with the name of the contractor and the words "Priced Bills of Quantities for Wexford Bridge," should be lodged at the same time. Otherwise the tender will not be considered bona-fide.

The sealed packages containing the priced Bills of Quantities will be returned unopened to the unsuccessful contractors on application. The contractor whose tender is accepted will be required to enter into a formal contract with the Wexford County Council and to give a satisfactory Bond for the performance of the Contract as provided for in the Conditions of Contract.

Prospective Contractors are to furnish evidence of their experience and competence in this class of work.

THOMAS F. McDERMOTT,  
Secretary,  
Wexford County Council.

County Hall,  
Wexford,  
Republic of Ireland.  
29th October, 1954.

## MISCELLANEOUS ADVERTISEMENTS.

*Situations Wanted, 3d. a word : minimum. 7s. 6d. Situations Vacant, 4d. a word : minimum, 10s. Other miscellaneous advertisements, 4d. a word : 10s. minimum. Displayed advertisements, 30s. per column inch. Box number 1s. extra. The engagement of persons answering these advertisements is subject to the Notification of Vacancies Order, 1952.*

**Advertisements must reach this office by the 23rd of the month preceding publication.**

## SITUATIONS VACANT.

**SITUATIONS VACANT.** Clarke, Nicholls & Marcel, consulting engineers, require in their London office, for reinforced concrete work designers and draughtsmen-detailers. Permanent positions. Good prospects. Apply in writing to 21 WESTBOURNE GROVE, LONDON, W.2.

**SITUATION VACANT.** Reinforced concrete designer-draughtsman required by ASHMORE, BENSON & CO., Stockton-on-Tees. Applicants should be fully experienced in designing and detailing reinforced concrete structures, foundations, and other civil work. Apply stating age, experience, etc., quoting Reference D, to Staff Personnel Officer.

**SITUATIONS VACANT.** Experienced reinforced concrete detailers and site engineers required by consulting engineers in their Sunbury office. Five-days' week, permanent position, good salary and prospects. Apply, stating age and experience, to J. H. COOMBS & PARTNERS, Thames Corner, Sunbury-on-Thames.

**SITUATION VACANT.** Structural engineer (qualified), with considerable experience in competitive reinforced concrete design, required urgently by reinforced concrete engineers in Nairobi, Kenya. Good salary, home leave, bonus, and pension schemes. Applications will be treated in strict confidence. Write Box SE/171, c/o 95 Bishops-gate, London, E.C.2.

**SITUATIONS VACANT.** Reinforced concrete detailers, able to undertake simple design and preferably with a working knowledge of detailing structural steelwork, required by consulting engineer, Westminster. Progressive salary scale, and starting pay commensurate with ability and experience. Apply, giving full details, to Box 4089, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATIONS VACANT.** Reinforced concrete designers and draughtsmen required immediately in civil engineering department of The Coppee Co. (G.B.), Ltd., for colliery structures. Some experience in quantities desirable. Steelwork an advantage but not essential. Pension scheme in operation. Write, stating age, qualifications, experience, and salary required, to THE COPPEE CO. (G.B.), LTD., 140 Piccadilly, London, W.1.

**SITUATIONS VACANT.** Reinforced concrete designers and detailers required by consulting engineer to work in Survey office. Good working conditions and five-days' week. Salaries £500/£900 per annum according to experience and ability. Permanent positions with excellent prospects. Apply, giving full details, to Box 4090, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Structural engineer required by civil engineering contractors in London, S.W.3, for the design of reinforced concrete structures. Applicants need not have specialised in concrete design but should be familiar with normal methods of structural analysis. Permanent position. Salary in accordance with qualifications and experience. Please reply in own handwriting to Box 4092, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Designer-draughtsman required for London office of well-known reinforced concrete engineering contractors. Experience in reinforced concrete frames, floors, roof and staircase construction essential. Progressive post, pension scheme, alternate Saturdays. Write fully experience, and salary required. Box 4097, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Reinforced concrete detailer required for London office. Previous experience in similar capacity necessary. Attractive conditions of employment. Apply in writing giving brief particulars of education, experience, age, and quoting L.128, to BRAITHWAITE & CO. ENGINEERS, LTD., 14-16 Regent Street, London, S.W.1.

**SITUATIONS VACANT.** Reinforced concrete detailers required by consulting civil and structural engineers. Five-days' week. Berkhamstead, Herts., area. Write, stating age, experience, and salary required. Box 4098, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Civil engineering draughtsman required by consulting firm in Victoria area. Technical education on basis of taking H.N.C. studies. Previous experience of reinforced concrete rather than steelwork advantageous. Salary according to experience, and minimum age about 25 years. Details to Box 4099, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Designer-detailer (reinforced concrete) required by consulting engineers, Westminster. Salary, based on experience and technical education, would be £600 upwards. Post progressive both for position and remuneration. Details of experience, employment, and age to Box 4100, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATIONS VACANT.** Tarmac Limited require the following staff at head office. (1) Senior estimator for concrete products, able to read drawings and prepare own quantities. Up-to-date experience essential. (2) Architectural draughtsmen, fully qualified and able to work with the minimum of supervision. These appointments are permanent and well paid. Write, giving full details of experience and salary required, to CLERICAL MANAGER, TARMAC, LTD., Ettingshall, Wolverhampton.

**SITUATION VACANT.** Bates, Ltd., have vacancy for structural engineering assistant for design and detailing of reinforced concrete structures and precast work. Salary according to qualifications. Five-days' week, bonus, and pension schemes. Assistance in finding housing accommodation if required. Write stating particulars of age, education, and experience, to WATES, LTD., 1258-60 London Road, London, S.W.16.

**SITUATION VACANT.** British Railways have a vacancy at Paddington for a draughtsman experienced in design of reinforced and prestressed concrete bridges and structures. Post offers permanency, opportunity for promotion, and carries advantages of superannuation and rail-travel privileges. Apply, giving age, experience, etc., to CIVIL ENGINEER'S OFFICE, Paddington, London, W.2.

**SITUATION VACANT.** Consulting engineers require engineer to take charge of reinforced concrete design. Applicants must be corporate members of the Institution of Civil Engineers and preferably hold engineering degree of a British university. At least fifteen years' experience of reinforced concrete design and construction, and control of office staff essential. For application forms, a postcard should be addressed to SIR BRUCE WHITE, Wolfe Barry & Partners, 1 Lygon Place, London, S.W.1.

**SITUATIONS VACANT.** Civil engineers required for travelling site supervision, or as assistant estimator. Degree and five years' site and office experience essential. Write Box 4102, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

Team required (agent, engineer, and leading tradesmen), specialised in reinforced concrete bunkers, silos, and other reinforced concrete structures for succession of contracts in United Kingdom. Four-figure salary, car, and allowances to agent, with prospect of taking over development of department as contracts' manager in expanding Civil Engineering organisation. Bonus paid on results. Only top-class men required, who must produce evidence of full control on well-planned work, including properly-engineered formwork and methods of placing concrete to secure rapid completion and high standard of work with minimum supervision. State full details in strict confidence. Box P 851, LEE & NIGHTINGALE, North House, North John Street, Liverpool.

(Continued on page lx.)

**MISCELLANEOUS ADVERTISEMENTS.***(Continued from page 1ix.)*

**SITUATION VACANT.** Reinforced concrete detailer-draughtsman required for progressive position with consulting engineer with offices in London, S.W.1 and W.1 areas. State training, experience, and salary required. Five-days' week and pension scheme. Box 4103, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATIONS VACANT.** The British Reinforced Concrete Engineering Co., Ltd., have vacancies for reinforced concrete designers and detailers, with experience, in their Stafford, London, Liverpool, Bristol, Newcastle-on-Tyne, and Glasgow offices. Staff pension scheme and five-days' week. Apply in writing to CHIEF ENGINEER, Stafford.

**SITUATIONS VACANT.** Experienced designers required for reinforced concrete specialists' office on Tyneside. Seven to ten years' experience of every-day design jobs is essential. Graduateship or Associate Membership of the Institution of Structural Engineers is a desirable qualification. Good salary and opportunities for promotion for good men anxious to make progress. Non-contributory pension scheme and profit-sharing bonus in operation. Write, giving qualifications, experience, age, and salary required to THE SQUARE GRIP REINFORCEMENT CO. (GATESHEAD), LTD., Team Valley Trading Estate, Gateshead 11, Co. Durham.

**SITUATIONS VACANT.** Consulting structural engineers with much varied and interesting work require assistants with at least two years' office experience in designing and detailing steel and reinforced concrete frameworks and foundations following Graduateship and National Service. Salary £500 to £700. Apply ANDREWS, KENT & STONE, 60 Wardour Street, London, W.1. Telephone Gerrard 9341.

**SITUATIONS VACANT.** Designer-detailer and detailer experienced in reinforced concrete. Knowledge of steel work and prestressed concrete an advantage but not essential. Varied and interesting work with scope for initiative. No Saturdays. Good salaries to right applicants, who should apply, stating full particulars, to ENGINEERING DEPARTMENT, FARMER & DARK, Romney House, Tufton Street, London, S.W.1.

**SITUATION VACANT.** Reinforced concrete detailer, with some knowledge of design, required by progressive Midland firm. Opportunity to supervise structural section of drawing office. Interesting work and good prospects. Box 4104, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATION VACANT.** Applications are invited for the post of research and development assistant to investigate, institute, and direct research into new building methods and materials. Applicants should hold recognised professional qualifications and preferably have experience in structural engineering. Write giving full particulars of experience, etc., to PERSONNEL DEPARTMENT, TAYLOR WOODROW HOMES, LTD., Ruislip Road, Southall, Middlesex.

**SITUATIONS VACANT.** Engineer-designers required. Structural steel, reinforced concrete, foundations, etc. Salaries £350 to £600. Particulars to C. B. BROWN & PARTNERS, 123 Victoria Street, London, S.W.1.

**SITUATIONS VACANT.** Two vacancies exist in the London office of large civil engineering contractors for reinforced concrete designer-draughtsmen. The work is of an extremely varied nature and offers good scope for man with initiative to advance himself. Ideal conditions. Good salary, bonus, and luncheon vouchers. Pension scheme operates. Apply in writing to Box 4105, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

**SITUATIONS VACANT.** Civil engineering draughtsmen. Imperial Chemical Industries, Ltd., Billingham Division, have vacancies for experienced civil engineering draughtsmen for work on major factory extensions involving design and detailing of reinforced concrete foundations and structures, roads, drainage, and water systems. Candidates should have qualifications equivalent to the Higher National Certificate. Attractive salaries and conditions. Pension fund. Write for application forms to the STAFF MANAGER, IMPERIAL CHEMICAL INDUSTRIES, LTD., Billingham Division, Billingham, Co. Durham, quoting reference Z.1.

**SITUATION WANTED.**

**SITUATION WANTED.** Structural engineer, 31, qualified and experienced, seeks further appointment. Box 4101, CONCRETE AND CONSTRUCTIONAL ENGINEERING, 14 Dartmouth Street, London, S.W.1.

The PORT OF LONDON AUTHORITY invite applications for positions as DRAUGHTSMEN at their Head Office. Commencing salaries will be fixed within the appropriate scale according to qualifications and experience. Increments are annual.

**1. 1st Class Draughtsmen (Civil).**

**Salary Scale:**—£627 10s. per annum by £26 5s. to £758 15s. per annum.

**Requirements:**—Ability to design and detail a wide variety of structures and buildings in reinforced concrete, steel and timber, and work with minimum supervision.

**2. 2nd Class Draughtsmen.**

**Salary Scale:**—£552 per annum by £23, by £21 to £596 per annum.

**(a) Civil.**

**Requirements:**—Ability to detail structures and buildings in reinforced concrete, steel and timber, with the minimum supervision, and execute minor designs. Experience in making site surveys would be an advantage.

**(b) Survey and General Duties.**

**Requirements:**—Ability to carry out land and building surveys and plot the results, and to carry out general draughtsman's duties.

**3. 3rd Class Draughtsmen.**

**Salary Scale:**—£425 10s. per annum by £17 5s. by £23 to £506 per annum.

**(a) Civil.**

**Requirements:**—Ability to detail buildings as in 2(a) above, under supervision. Experience in making site surveys would be an advantage.

**(b) Survey.**

**Requirements:**—Ability to survey land and buildings, under supervision.

Application forms may be obtained from the ESTABLISHMENT OFFICER, Port of London Authority, Trinity Square, London, E.C.3.

**COVENTRY CORPORATION.**

require (a) ASSISTANT STRUCTURAL ENGINEER, grade APT VII (£735-810). Experience in reinforced concrete design in engineering and building structures essential. Final Examination of Institution of Civil or Structural Engineers preferred;

(b) TRACER/DRAUGHTSMAN, grade Misc. III or IV (£395-460 or £440-520), according to qualifications and experience, plus £26 (males) or £19 10s. od. (females) Local Award in certain circumstances. Experience in Civil Engineering and Structural drawing and working knowledge of reinforced concrete essential.

Application forms from CITY ENGINEER, Council House, Coventry, returnable by 21st December.



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concrete reinforcement that we have decided to manufacture it exclusively. And, because we believe in associating the title of the company with the trade name of the product, we have changed our name

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Head Office  
Tel: 444



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Tel: Grosvenor 8371



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Charing Cross, C.3  
Tel: Douglas 5906



**NEWCASTLE**  
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**BRC**  
Specialists in  
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and Suppliers of  
Reinforcement

**THE BRITISH REINFORCED CONCRETE ENGINEERING CO. LTD., STAFFORD**  
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